Instruction Manuals

ELECTRON MICROSCOPE

TYPE EMU
MI-12951

INSTRUCTIONS

Manufactured by
RCA VICTOR DIVISION
of
RADIO CORPORATION OF AMERICA
Camden, New Jersey, U. S. A.

IB-39008

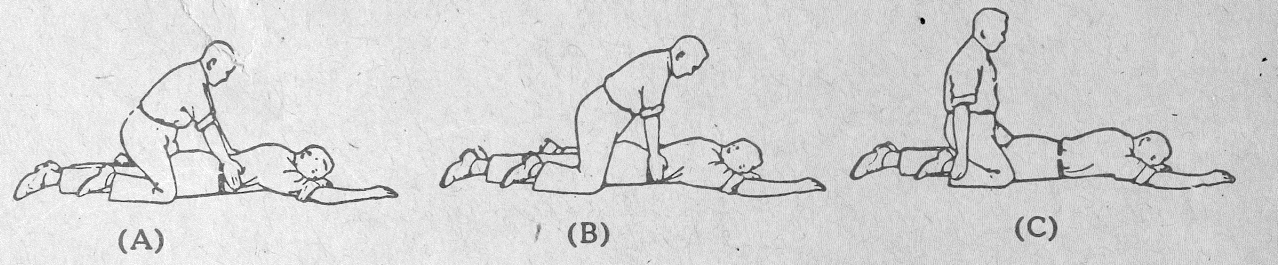
WARNING

THE VOLTAGES EMPLOYED IN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER HUMAN LIFE AND EVERY REASONABLE PRECAUTION HAS BEEN OBSERVED IN DESIGN TO SAFEGUARD THE OPERATING PERSONNEL. AN IMPORTANT PART OF THE PROTECTIVE SYSTEM IS THE SERIES OF DOOR INTERLOCK SWITCHES AND ANY TAMPERING WITH THESE SWITCHES SHOULD BE PROHIBITED. THE POWER SHOULD BE REMOVED COMPLETELY BEFORE CHANGING TUBES OR MAKING INTERNAL ADJUSTMENTS.

FIRST AID IN CASE OF ELECTRIC SHOCK

1. PROTECT YOURSELF with dry insulating material.
2. BREAK THE CIRCUIT by opening the power switch or by pulling the victim free of the live conductor.

   DON'T TOUCH VICTIM WITH YOUR BARE HANDS until the circuit is broken.



3. LAY PATIENT ON STOMACH, one arm extended, the other arm bent at elbow. Turn face outward resting on hand or forearm.
4. REMOVE FALSE TEETH, TOBACCO OR GUM from patient's mouth.
5. KNEEL STRADDLING PATIENT'S THIGHS. See (A).
6. PLACE PALMS OF YOUR HANDS ON PATIENT'S BACK with little fingers just touching the lowest ribs.
7. WITH ARMS STRAIGHT, SWING FORWARD gradually bringing the weight of your body to bear upon the patient. See (B).
8. SWING BACKWARD IMMEDIATELY to relieve the pressure. See (C).
9. AFTER TWO SECONDS, SWING FORWARD AGAIN. Repeat twelve to fifteen times per minute.
10. WHILE ARTIFICIAL RESPIRATION IS CONTINUED, HAVE SOMEONE ELSE:
    (a) Loosen patient's clothing.
    (b) Send for doctor.
    (c) Keep patient warm.
11. IF PATIENT STOPS BREATHING, CONTINUE ARTIFICIAL RESPIRATION. Four hours or more may be required.
12. DO NOT GIVE LIQUIDS UNTIL PATIENT IS CONSCIOUS.

ERRATA
TO
INSTRUCTION BOOK
FOR
ELECTRON MICROSCOPE, TYPE EMU-1

(This errata supersedes erratas IB-39008-a and IB-39008-b)

DISPOSITION: To be inserted in Instruction Book IB-39008

The following changes should be made in the above mentioned instruction book:

Page	
3	"Bellows Stock No. 48113" should read "Bellows Stock No. 44051"
4	in Figure 4, "Bellows Stock No. 48113" should read "Bellows Stock No. 44051"
43	47996, Cushion: change Stock No. to 47696
43	47997, Cushion: change Stock No. to 47697
45	48814, Relay: change Stock No. to 50792 and Drawing No. to 430560-501
46	61028, Resistor: change Stock No. to 34765
46	48159, Capacitor C-1: change Stock No. to 48157
47	19548, Socket: change Stock No. to 19458
47	48113, Bellows: change Stock No. to 44051
48	delete entire item Stock No. 48806 Pin Knob travel limit 891181-1
49	delete entire item Stock No. 48225 Connector Coil Male 878440-1
49	47108, Cap: change Stock No. to 48483
49	46603, Screen: change Stock No. to 47628
52	64199, Allen Wrench: change Stock No. to 64179
57	in Figure 20, 48113, Bellows: change Stock No. to 44051
58	in Figure 21, change Window, Electron Gun, Stock No. 48412 to Stock No. 48110
71	in Figure 45, change Cap Stock No. 47108 to Stock No. 48483
71	in Figure 45, change Screen Stock No. 46603 to Stock No. 47628
75	in Figure 50, change Spring Stock No. 4798 to Stock No. 47982
75	in Figure 50, change Shaft Pinion Stock No. 47986 to Stock No. 48808

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Camden, New Jersey, U.S.A.

Printed in U.S.A.

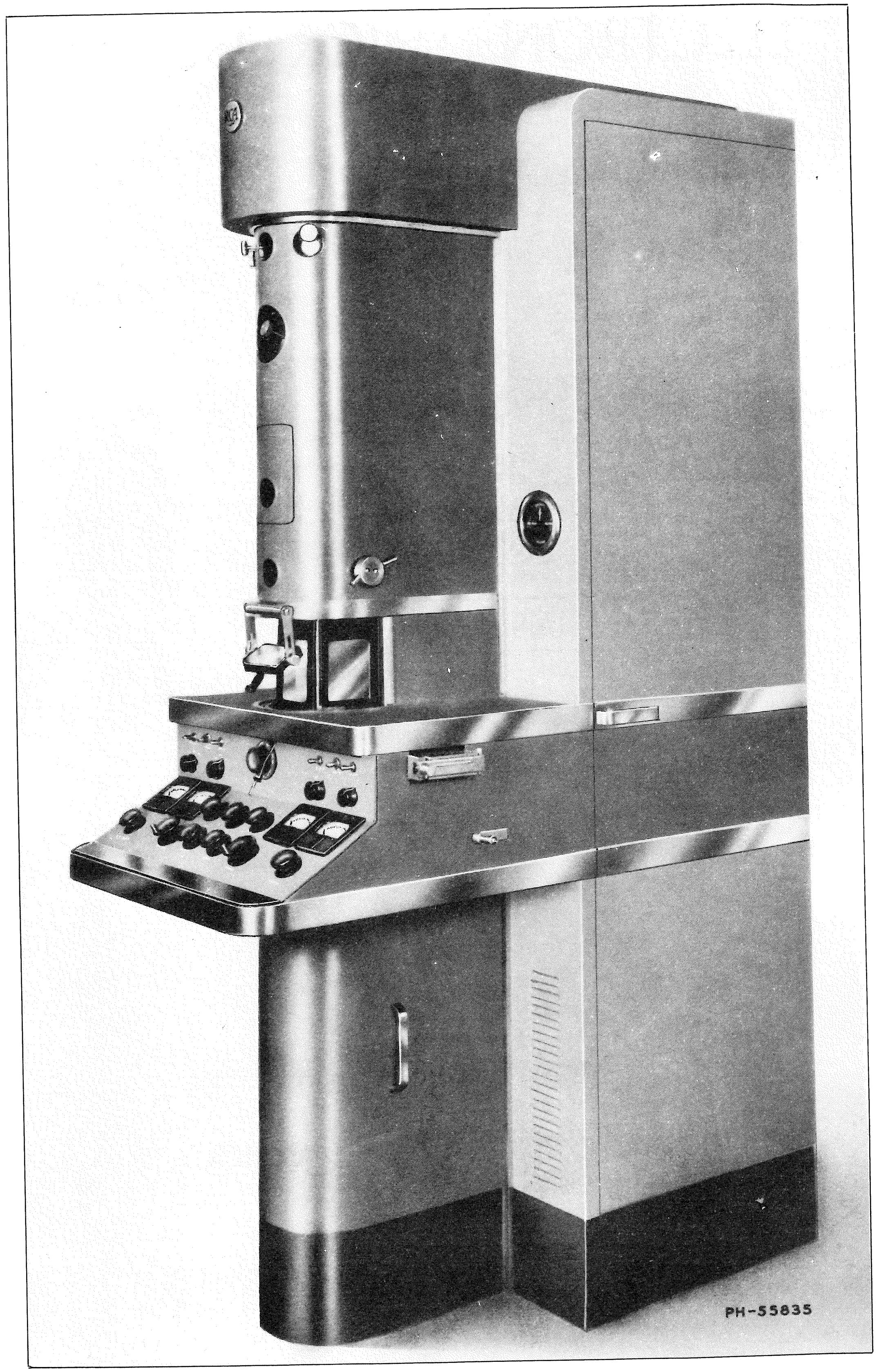

Figure 1—Electron Microscope, Type EMU, Oblique Front View

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TECHNICAL SUMMARY

EQUIPMENT

The Electron Microscope complete with associated equipment is identified as follows:

Designation	Power Required	Items		Quan.
MI-12951	115 volts, 60 cycles	Electron Microscope EMU-1	MI-12957	1
		Vacuum Pump (Hypervac 20)	MI-12936-B	1
		Voltage Stabilizer	MI-12959	1
		Accessory Kit	MI-12980-B	1
		Instruction Books	IB-39008	2
MI-12951-A	230 volts, 50 cycles	Electron Microscope EMU-1	MI-12957	1
		Vacuum Pump (Hypervac 20)	MI-12956-C	1
		Voltage Stabilizer	MI-12959-A	1
		Accessory Kit	MI-12980-B	1
		Instruction Books	IB-39008	2
MI-12951-B	115 volts, 50 cycles	Electron Microscope EMU-1	MI-12957	1
		Vacuum Pump (Hypervac 20)	MI-12956-C	1
		Voltage Stabilizer	MI-12959-B	1
		Accessory Kit	MI-12980-B	1
		Instruction Books	IB-39008	2

Electrical Characteristics:

Electronic Magnification (40 steps, 4 ranges)	100 to 20,000 diameters
Resolution	Better than 100 Angstrom Units

Anode Potential:

With respect to cathode	+ 50 kv.
With respect to instrument ground	zero

Power Supply Requirements:

MI-12951	115 volts, 60 cycles
MI-12951-A	230 volts, 50 cycles
MI-12951-B	115 volts, 50 cycles

Line rating	115 volts, 60 cycles, single phase
Power Consumption (Maximum)	1,500 watts
Maximum Allowable Line Voltage Variations	2.5 volts in 30 sec. minimum time

TUBE COMPLEMENT:

Item	Type	Quan.	Circuit Number in Instruction	Class of Tube
1	VR-150	2	V-5, V-21	Receiving
2	6L6	4	V-7, V-8, V-11, V-23	Receiving
3	12SJ7	3	V-16, V-22, V-24	Receiving
4	6Y6G	1	V-14	Receiving
5	6H6	1	V-10	Receiving
6	6SF5	1	V-6	Receiving
7	807	3	V-17, V-20, V-27	Power
8	5R4GY	2	V-3, V-4	Power
9	811	3	V-15, V-18, V-19	Power
10	8013A	3	V-28, V-29, V-30	Power
11	1616	2	V-1, V-2	Power
12	48249	1	Ionization Gauge (V-13)	Special
13	991	3	Indicators V-9, V-25, V-26	Neon
14		1	Thermocouple Gauge (V-12)	Special

Item 14 (V-12) must be ordered as thermocouple gauge for Electron Microscope Type EMU-1.

Items Number 12 and 13 should be ordered by type number, or stock number, from the Radio Corporation of America, Camden, New Jersey. Numbers 1 through 11 are standard tubes ordered through any tube dealer.

Mechanical Specifications:

Evacuation (maximum permissible pressure)	0.1 micron
Water Flow Requirement	3 cubic centimeters per second

Photographic Facilities:

Plate size	2 inches x 10 inches
Exposures per Plate	5

Overall Dimensions:

	Microscope	Mechanical Pump
Height	75 inches	17½ inches
Width	24 inches	13½ inches
Depth	42 inches	
Length		25 inches
Total Weight (net)	875 pounds	

INTRODUCTION

GENERAL PURPOSE AND FUNCTIONS OF THE RCA TYPE EMU ELECTRON MICROSCOPE

The RCA type EMU Electron Microscope, like the conventional light microscope, is intended to furnish enlarged images of minute objects or specimens. Through the use of an electron beam instead of light waves for illuminating the specimen, the Electron Microscope allows magnifications to be obtained which are considerably greater than those afforded by even the most perfect types of light microscopes. Magnifications as high as 25,000 diameters may be thus reached with the Electron Microscope. Moreover, as will be explained in this Instruction Book, magnification may be adjusted readily to suit particular conditions.

Provision is made, in the design of the type EMU Electron Microscope, for observing the magnified image visually on a fluorescent screen, as well as for recording this image on a photographic plate. A series of such photographs may be made successively without recharging the camera. As an additional feature, magnified stereoscopic micrographs can be taken, which give three-dimensional views of the specimen.

The field of application of the type EMU Electron Microscope is further extended through the inclusion, in the design of the instrument, of the necessary attachments and controls to obtain diffraction patterns by either reflection or transmission methods.

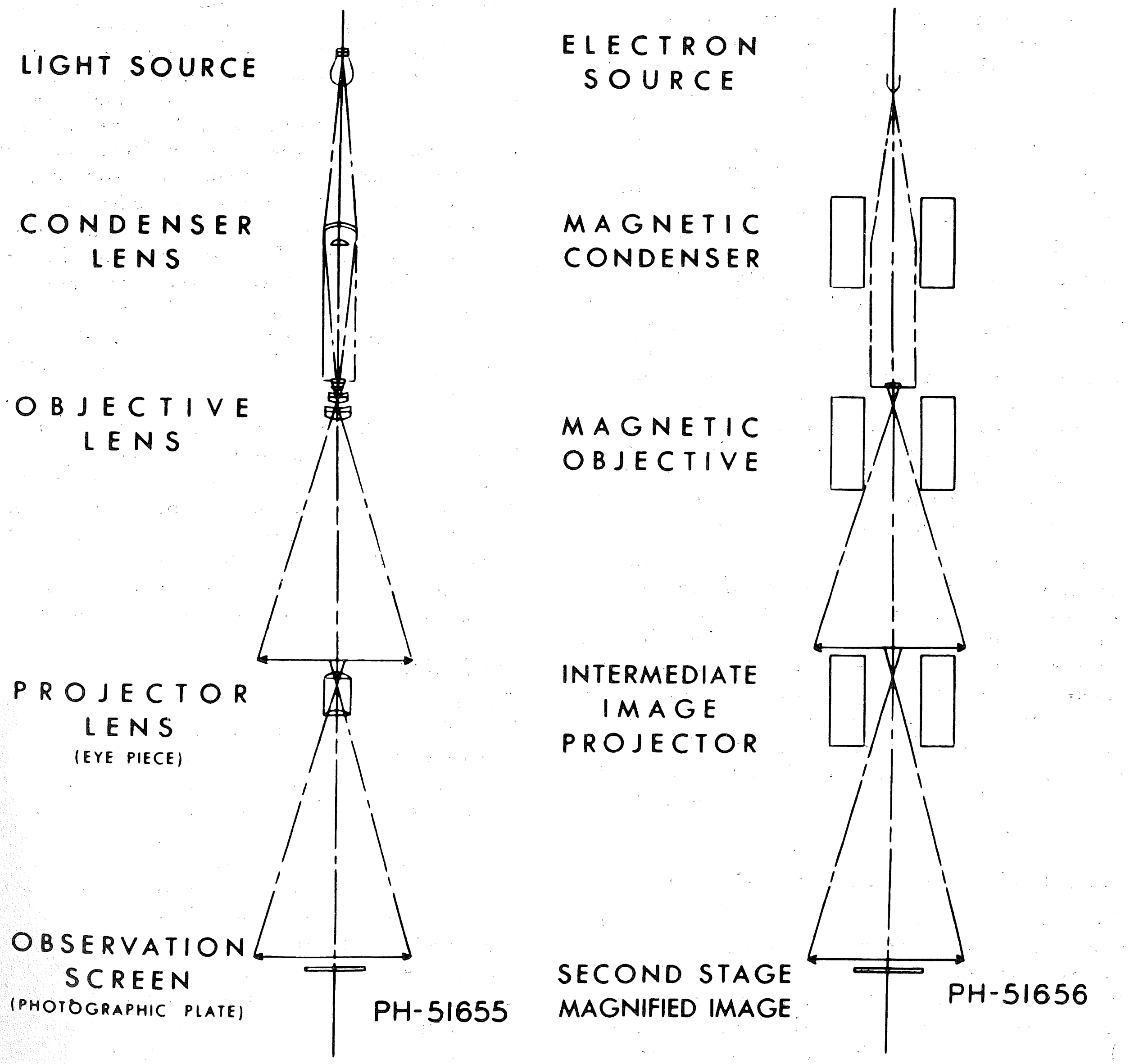

LIGHT SOURCE
CONDENSER LENS
OBJECTIVE LENS
PROJECTOR LENS (EYE PIECE)
OBSERVATION SCREEN (PHOTOGRAPHIC PLATE)
PH-51655
ELECTRON SOURCE
MAGNETIC CONDENSER
MAGNETIC OBJECTIVE
INTERMEDIATE IMAGE PROJECTOR
SECOND STAGE MAGNIFIED IMAGE
PH-51656

Figure 2—Analogy of Light and Electron

PHYSICAL CONSIDERATIONS

The basic principles of the Electron Microscope are in many respects analogous to those of the conventional light microscope. This similarity is illustrated in the drawing of Figure 2 which shows the essential elements of the light microscope at the left and of the electron microscope at the right.

Essentially, the light microscope consists of a light source, a condenser lens which controls the light on the specimen, a specimen stage which in the better grade of instrument incorporates means of moving the specimen in any direction in the plane of the stage, an objective lens which determines the ultimate quality of the image, and an eye-piece for visual observation of the image or a projector lens for micro-photography.

In the electron microscope, these elements are replaced by corresponding electronic elements. Thus, the light source becomes an electron source, and the solid light lenses are replaced by magnetic field lenses. Structural details, however, are quite different. Since electrons are absorbed and scattered by air, it is necessary to maintain a high vacuum throughout the entire electron path. The inherent nature of electrons, which makes a vacuum necessary, also requires a special type of specimen-mounting technique. Instead of glass slides and cover glasses, a much more "transparent" medium of support is employed.

Operation of the electron microscope is appreciably different from that of the light microscope, and in many ways is much simpler and more convenient. Focusing of the electron beam is determined by the power of the objective, and is therefore controlled simply by adjusting the current flowing through the objective coil, all distances remaining fixed. Similarly, no lenses need be changed to vary the magnification, which is controlled by varying the strength of the current flowing through the projector coil.

As in the case of glass lenses in the light microscope, the electromagnetic lenses of the electron microscope are subject to such defects as aberration and diffraction. These are reduced through the use of a limiting aperture. The optimum diameter of this aperture is that for which the effects of aberration and diffraction are equal. However, in actual practice, the opening differs from this optimum value to take into account the contrast and resolution desired with different types of specimens.

STABILITY CONDITIONS OF OPERATION

The effectiveness of a magnetic electron lens depends on the value of the current flowing through the exciting coil and on the velocity of the electron beam. In order, therefore, to obtain photographic records with all of the detail present in the electron image, it is imperative that the exciting current and electron accelerating voltage remain extremely constant during the time of exposure. It is a function of the power supply circuits incorporated in the design of the RCA Electron Microscope to insure the required high degree of constancy of the energizing voltages and other operating conditions.

Disturbing factors of another nature must also be eliminated. These include the effects of varying external magnetic fields, of random electrostatic potentials accruing on partially insulating surfaces in the electron path, and of mechanical vibration due to external sources such as nearby heavy machinery, railroads and motor trucks.

Varying external magnetic fields will produce extraneous effects in the electron image but such effects have been minimized in the RCA Electron Microscope by adequate shielding of the sensitive regions. The presence of electrostatic potentials, however, constitutes a somewhat more difficult problem. It has been found that a partially carbonaceous, semi-conducting material is deposited on all of the diaphragms which are in the direct path of the electron beam. When these deposits become sufficiently heavy, the potentials at the exposed surfaces may be considerably different from that of the metal aperture. The effect is most serious in the case of the objective lens where the image defects thus introduced are sufficient to limit the resolution. At present, the simplest method of eliminating this difficulty is to replace the limiting aperture at periodic intervals. The resolution of the RCA Electron Microscope will vary from about 30 Angstrom units (equal to 30 x 10^{-7} millimeters), with a new aperture to about 100 Angstrom units at the end of one month of normal operation.

Little or no difficulty is to be expected from external mechanical vibration provided normal precautions are observed at installation. In the RCA Electron Microscope, independent displacement of any of the components of the magnification system is almost entirely overcome by rigid construction of the sensitive elements and by shock-mounting of the complete instrument.

SPECIMENS

The intensity distribution in an electron image formed by the microscope is, for the major part, due to variations in the scattering power of different portions of the specimen. In general, absorption of the electrons does not occur in the extremely thin type of specimens best suited for electron microscope observation. Such absorption actually is to be avoided since the energy released by the absorbed electrons appears as heat, and may be sufficient to raise the temperature of the specimen to a point where decomposition and structural changes may occur. It has been found, in practice, that satisfactory images will be obtained with specimens up to one micron in thickness, using electrons accelerated by potentials of the order of 50 kilovolts.

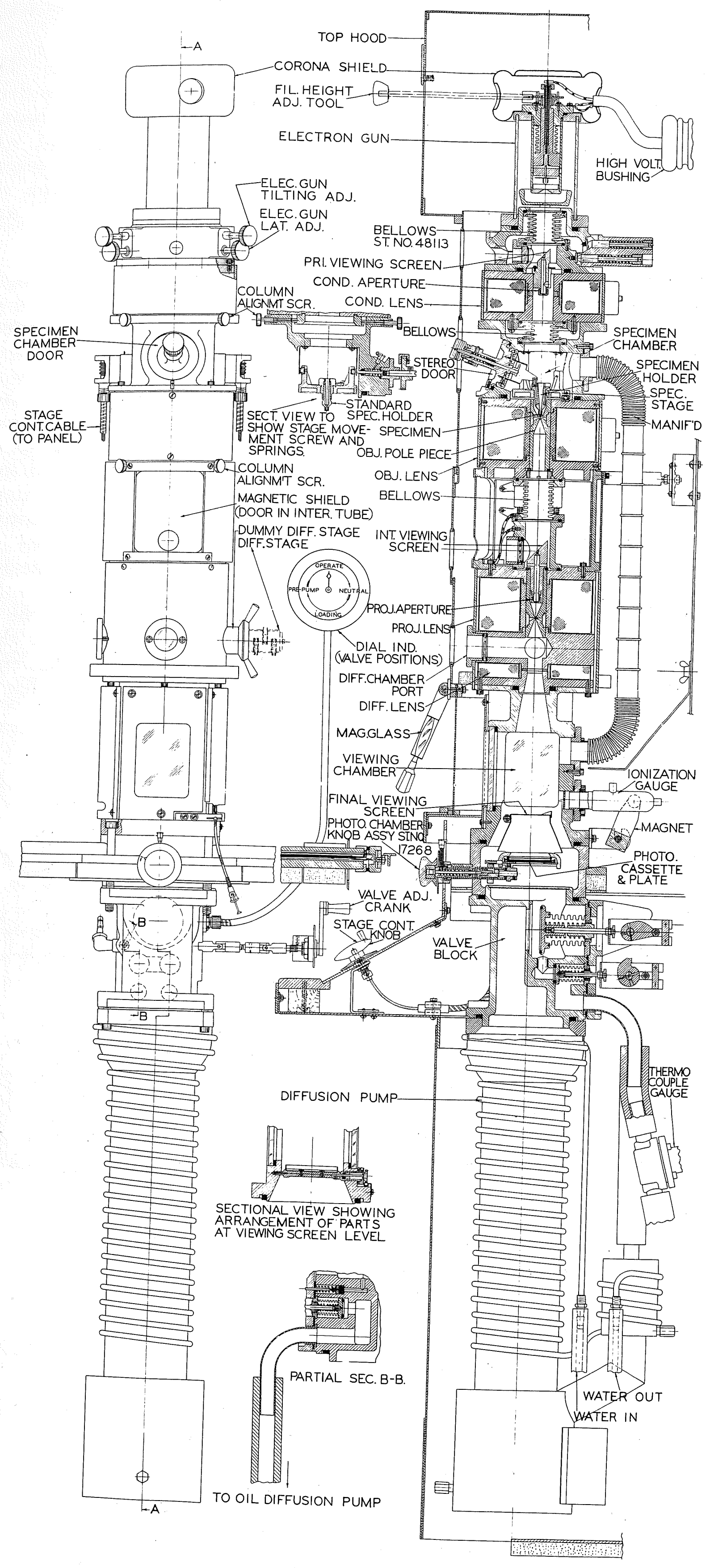

A
TOP HOOD
CORONA SHIELD
FIL. HEIGHT ADJ. TOOL
ELECTRON GUN
HIGH VOLT. BUSHING
ELEC. GUN TILTING ADJ.
ELEC. GUN LAT. ADJ.
BELLOWS ST. NO. 48113
PRI. VIEWING SCREEN
COND. APERTURE
COLUMN ALIGNM'T SCR.
COND. LENS
BELLOWS
SPECIMEN CHAMBER DOOR
STEREO DOOR
SPECIMEN CHAMBER
SPECIMEN HOLDER
SPEC. STAGE
MANIF'D
STANDARD SPEC. HOLDER
STAGE CONT. CABLE (TO PANEL)
SECT. VIEW TO SHOW STAGE MOVEMENT SCREW AND SPRINGS.
SPECIMEN
OBJ. POLE PIECE
COLUMN ALIGNM'T SCR.
OBJ. LENS
BELLOWS
MAGNETIC SHIELD (DOOR IN INTER. TUBE)
DUMMY DIFF. STAGE DIFF. STAGE
INT. VIEWING SCREEN
OPERATE
PRE-PUMP
NEUTRAL
LOADING
PROJ. APERTURE
PROJ. LENS
DIAL IND. (VALVE POSITIONS)
DIFF. CHAMBER PORT
DIFF. LENS
MAG. GLASS
VIEWING CHAMBER
IONIZATION GAUGE
FINAL VIEWING SCREEN
PHOTO. CHAMBER KNOB ASS'Y ST. NO. 17268
MAGNET
PHOTO. CASSETTE & PLATE
VALVE ADJ. CRANK
STAGE CONT. KNOB
VALVE BLOCK
B
B
THERMO COUPLE GAUGE
DIFFUSION PUMP
SECTIONAL VIEW SHOWING ARRANGEMENT OF PARTS AT VIEWING SCREEN LEVEL
PARTIAL SEC. B-B.
WATER OUT
WATER IN
TO OIL DIFFUSION PUMP
A

Figure 3—Electron Microscope, Outline Drawing (WW-307499)

DESCRIPTION

GENERAL LAYOUT OF THE ELECTRON MICROSCOPE

An overall view of the RCA type EMU Electron Microscope is shown in the photograph of Figure 1. An outline diagram of the assembly is given in Figure 3. Essentially, the main body of the microscope consists of a vertical column about three feet high and six inches in diameter, made up of a number of sections which are joined together. The joints are provided with air-tight rubber gaskets, permitting the required low pressure to be obtained within the column assembly. For this purpose, the column is connected to a diffusion pump and a rotary pump.

Mounted at the top of the microscope column is the electron gun assembly which comprises a cathode or source of electrons and an anode whose potential provides the proper acceleration and direction for these electrons. Then, from top to bottom along the column, are located the condenser aperture and primary viewing screen, the magnetizing coil of the condenser aperture and primary viewing screen, the magnetizing coil of the condenser lens, the specimen chamber, objective lens coil, projector aperture and intermediate viewing screen, the projector-diffraction lens coils, the final viewing screen, and the photographic chamber. Glass windows are provided in the wall of the column to allow for examination of the images on the viewing screens. Both the specimen chamber and photographic chamber are provided with doors which may be opened when there is normal air pressure in the column so that specimens and photographic plates may be inserted into and removed from the column.

At the rear of the column assembly is a vertical cabinet which contains the necessary vacuum tubes, transformers, and other circuit elements for the generation and accurate regulation of the supply voltages which energize the electron gun and the three lens coils. Two electronic vacuum gauges are also provided, with their associated circuits, to indicate the pressure within the microscope. All operating controls are mounted on the control panel of the instrument within easy reach of the operator.

A description of these various component parts of the microscope is given in the following pages. For ease of discussion the components have been grouped according to their respective functions, a thorough understanding of which will greatly facilitate the operation of the apparatus as a whole. These groups refer respectively to the magnification system; the specimen, viewing, and photographic facilities; the vacuum system; and the electrical system.

MAGNIFICATION SYSTEM

The magnification system comprises the electron source or electron gun assembly, the condenser lens, the objective lens, the projector-diffraction lens, and associated pole pieces. These various units are described below. They are assembled through substantially cylindrical sections, with which they form the microscope body or column. The sections are provided with suitable doors, windows, aligning and centering controls, and constitute, respectively, the specimen chamber, intermediate chambers and photographic chamber.

Electron Gun—The function of the electron gun is to form the electron beam and direct it down the microscope column through the condenser lens. The electron gun consists mainly of (a) the cathode, maintained at 50 kilovolts with respect to ground and (b) the anode, at ground potential. The cathode structure supports the filament assembly (Stock No. 44511) which consists of a mica support and insulating disc, studs for supporting the actual filament, and studs to provide electrical connections. The filament itself is made up of 0.004″ diameter tungsten wire, 0.5″ long, bent in the form of a "V" with the free ends spot welded to the supporting studs. The radius of bending at the filament apex must be as small as possible, of the order of 0.005″, and the height of the filament apex with respect to the face of the mica disc should be close to 0.4″.

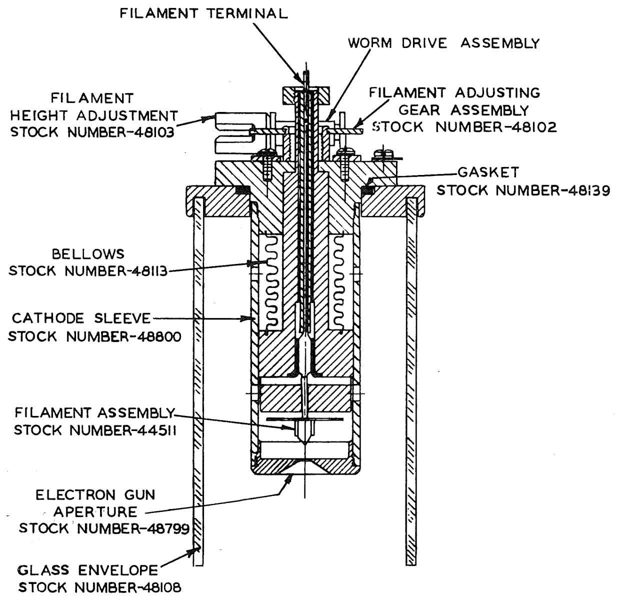

FILAMENT TERMINAL
WORM DRIVE ASSEMBLY
FILAMENT HEIGHT ADJUSTMENT STOCK NUMBER-48103
FILAMENT ADJUSTING GEAR ASSEMBLY STOCK NUMBER-48102
GASKET STOCK NUMBER-48139
BELLOWS STOCK NUMBER-48113
CATHODE SLEEVE STOCK NUMBER-48800
FILAMENT ASSEMBLY STOCK NUMBER-44511
ELECTRON GUN APERTURE STOCK NUMBER-48799
GLASS ENVELOPE STOCK NUMBER-48108

Figure 4—Electron Gun Assembly
(*M*-439171)

The electron beam is constituted by electrons emitted from the apex of the "V"-shaped filament. These electrons first pass through a 0.100″ diameter aperture in the cathode shield and are then accelerated toward a 3/16″ diameter aperture in the anode.

The filament assembly may be raised or lowered, along the vertical axis of the microscope, with respect to the cathode shield by inserting the hard rubber gun adjustment tool through the hole covered by the RCA monogram on the front of the top hood. **CAUTION:** THIS ADJUSTMENT SHOULD NOT BE MADE WITH ANY TOOL OTHER THAN THAT SUPPLIED WITH THE INSTRUMENT. The pin on the end of the tool fits into a slotted cup on top of the gun assembly. Clockwise rotation of the tool lowers the filament, while counter-clockwise rotation raises the filament.

Four screws at the front of the column near the base of the gun provide angular and lateral adjustment of the gun. The upper pair of screws allow angular or "tilt" adjustment of the entire electron gun. The lower pair of screws drive the gun laterally at right angles to the axis of the column. Thus, after the electron beam has been directed parallel to the axis of the microscope by means of the "tilt" screws, the beam may then be made to coincide exactly with the aperture in the condenser lens. To facilitate the aligning of the beam with the condenser lens, a port is provided in the base of the gun assembly, through which a cross-section of the beam may be seen.

Condenser Lens—The condenser lens controls the concentration or intensity of the electron beam on the specimen. The condenser lens consists of an iron-clad coil with a gap at about the middle of the central opening. The lens is provided with an aperture 0.025″ diameter supported by a holder, the upper part of which forms the fluorescent primary viewing screen. This screen can be seen through the port in the gun assembly base. Four screws, located just below the coil, allow alignment of the condenser coil-electron gun system with the rest of the column.

Objective Lens—The objective lens, through which the electron beam passes next, forms an image (intermediate image) of the specimen in a plane just above the projector lens.

The objective lens is similar in appearance and construction to the condenser lens, except that the central opening contains a removable pole piece assembly. The objective lens forms an intermediate image, which can be viewed on the intermediate viewing screen, at a magnification of about eighty diameters. The image is focused by adjusting the objective current. To align the axis of the objective and the illuminating system with the axis of the projector, an adjustment is provided just below the objective.

Projector-Diffraction Lens—The final lens in the electron optical system is a double lens. Two separate windings and gaps make up the two lenses which are constructed on a single spool and enclosed in a single outer shell. For microscopy, only the projector coil section is energized, by turning the projector-diffraction switch to "Proj." This lens contains a removable pole piece, similar to the objective pole piece, and supports the intermediate viewing screen which also carries the 0.050″ diameter projector aperture. The projector lens magnifies the intermediate image obtained from the objective lens and projects it on the final viewing screen for visual examination, or on the photographic plate. The magnification developed by the projector lens depends on the pole piece and the current through the projector coil.

If the instrument is used for obtaining diffraction patterns instead of micrographs, the projector lens current is turned off, and the diffraction lens current turned on in its place. The diffraction lens provides a low power focusing system for the diffracted rays.

Electrical Connection to Lens Coils—The electronic circuits of the microscope are arranged to accurately regulate the current in the lens coils, and the regulation obtains for each chosen value of current. The lens coil connector plugs should not be disconnected when the current through the lens is turned on, because this action will considerably overload the regulators and damage the coils from inductive kickback. If there is no current flow indication at the test meter for any lens circuit, the defective circuit should be turned off immediately. The regulating circuit, the connecting cable and plug, and the lens coil itself should be checked to ascertain the cause of the difficulty. In manufacture, all lens coils are tested for quality of insulation by application of 1,000 volts to ground.

Pole Pieces—Each lens contains a pole piece, specifically designed for its particular function. The inner configurations of these pole pieces, as well as other components which come in contact with the electron beam must, for proper operation, be kept absolutely clean. This matter of cleanliness is treated in detail in a later section, under the heading "Cleaning Pole Pieces."

The condenser pole piece is a fixed part of the lens, and cannot be removed for cleaning. Its aperture is comparatively large, and therefore does not require more than routine inspection for dirt or other foreign materials.

The objective and projector pole pieces are made of brass and soft magnetic iron, and should be handled with care. In order to prevent scoring and binding of the threads when screwed tightly, a small amount of octoil is applied on the threads and bearing surfaces. Cleaning instructions are given in the maintenance section of this book.

The projector pole piece assembly is furnished with two brass spacers. If the short spacer is used there will be a gap of 3/64″ between the two soft iron parts of the pole piece. This gives a magnification range of about from 7,500 to 22,000 diameters as the projector lens current is raised from minimum to maximum. If the long spacer is used, the gap is 10/64″, and the magnification range is about from 4,000 to 11,000. If no spacer is used, and only the top half of the pole piece is used, the magnification range is about from 700 to 4,000. If the microscope is used with no pole piece, the magnification range is about from 75 to 750.

Electron Diffraction Unit

The Diffraction Unit permits the type EMU Electron Microscope to be used interchangeably as an electron diffraction camera or an electron microscope. The Diffraction Unit includes a projector lens as well as a diffraction focusing lens and means for holding and adjusting specimens for diffraction examinations. Diffraction patterns may be obtained by either reflection or transmission (powder) methods. Specimens for transmission studies are mounted and supported on standard 200 mesh screens, according to the same techniques employed for micrograph work. Reflection specimens are supported on a special holder and may have the following maximum dimensions: 0.25″ square by 0.063″ thick. If the reflection specimen holder is not used, slightly thicker specimens may be employed. In many cases, it is possible to produce micrographs of a given specimen and then transfer the specimen to the Diffraction Unit and obtain a diffraction pattern of the same substance on the same photographic plate.

SPECIMEN VIEWING AND PHOTOGRAPHIC FACILITIES

Microscope Specimens

The specimen to be examined is inserted in the path of the electron beam between the condenser lens and the objective lens. It is mounted on an eighth-inch diameter, 200-mesh wire screen and placed in a special holder which is supported on a movable stage inside the column.

Specimen Holders

There are two types of specimen holders: the standard holder (Stock #48390) and the stereoscopic holder (Stock #48404). With each holder, the screen is inserted in the small cap, specimen side down, and then the cap is pushed onto the end of the holder as far as possible.

The standard holder is made of two pieces, one threaded into the other to allow vertical adjustment. A set screw is provided to lock the two parts together when adjusted. The holder should be adjusted in length so that when it is assembled with a specimen screen in place, the cap will clear the objective pole piece by an amount sufficient to give the greatest possible magnification consistent with free movement of the stage. This positioning is accomplished by trial and error, inserting the loaded holder and decreasing the specimen-objective distance until the movement of the image becomes erratic.

The stereo specimen holder is made in two parts: an outer part which has the same outside dimensions as the standard specimen holder, and can replace the latter in the specimen chamber; and an inner part which is a cylindrical tube with the specimen clamped at its lower end. The central axis of the outer part coincides with the incident electron beam when in operating position. The central axis of the inner part may be adjusted to coincide with the incident electron beam or to be tilted 4° on either side of the beam.

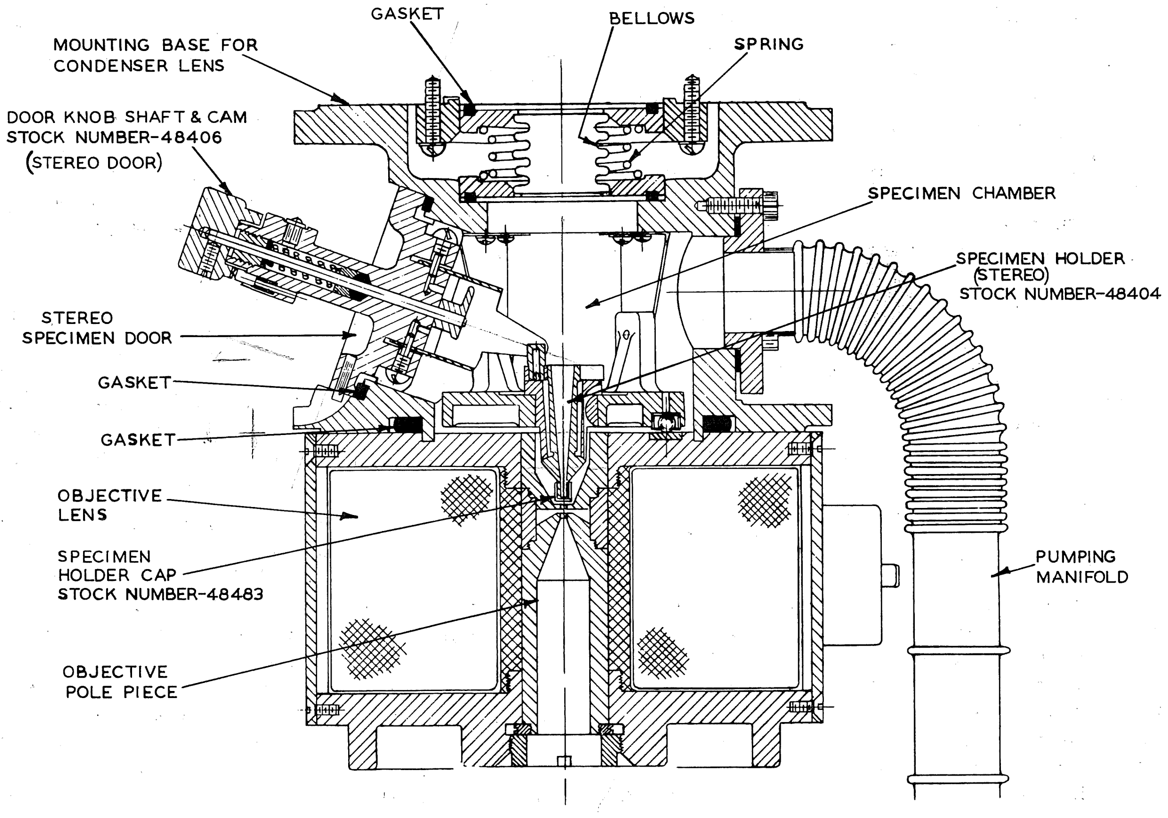

GASKET
BELLOWS
MOUNTING BASE FOR CONDENSER LENS
SPRING
DOOR KNOB SHAFT & CAM STOCK NUMBER-48406 (STEREO DOOR)
SPECIMEN CHAMBER
SPECIMEN HOLDER (STEREO) STOCK NUMBER-48404
STEREO SPECIMEN DOOR
GASKET
GASKET
OBJECTIVE LENS
SPECIMEN HOLDER CAP STOCK NUMBER-48483
PUMPING MANIFOLD
OBJECTIVE POLE PIECE

Figure 5—Specimen Chamber and Objective Lens (P-722674)

To make this adjustment, turn the handle on the specimen chamber door. The handle is connected to an internal fork that tilts the inner cylinder which carries the specimen. When the knob is turned to the right, the specimen holder is turned to to the right, and conversely a turn to the left takes the holder to the left. After the holder has been placed in either position, right or left, the handle must be returned to the central position, with the control knob dot at the top. The return position prevents interference with the fork by permitting free movement of the stage and specimen holder.

Specimen Stage

Directly above the objective lens is the specimen stage within the specimen chamber. Both the specimen stage and the holder may be moved in any desired direction in the horizontal plane within the chamber by two position controls, which are connected through worm gears and flexible shafts to the two unlabeled, handwheel knobs on the control panel and are calibrated from 1 to 10.

Intermediate Image Viewing Screen

Between the objective and projector lenses are the intermediate tube and port for viewing the intermediate image. The image produced by the objective is observed on a fluorescent screen situated just above the projector. As this image is important for the alignment of the instrument, a port is provided through which the operator may observe the image.

Photographic Chamber Viewing Screen

The final image is observed on the fluorescent screen at the base of the microscope column. The viewing screen has a square marked on it which indicates the portion of the image which will be photographed if an exposure is made. The center of the screen is also marked to assist in centering images. Especially helpful in adjusting the focus of the image and providing additional magnification is a 2½ X magnifying glass, attached in front of the viewing chamber.

Photographic Chamber

The fluorescent screen is raised or lowered by an external gear control and flexible cable release. When photographic records are made the fluorescent screen which acts as a shutter must be raised to allow the electron image to fall directly on the photographic plate immediately below. The 10″ by 2″ photographic plates which are used allow a series of five 2″ x 2″ exposures to be made, with the focus slightly changed from one exposure to the next. Thus the loading time per picture is reduced, and the ultimate resolving power of the microscope can be exploited. The exposure times vary from one to several seconds.

VACUUM SYSTEM—The electron beam, which takes the place of the light source in the Electron Microscope, requires a vacuum chamber for its existence and application. Figuratively, the RCA Electron Microscope is a cathode ray vacuum tube of large dimensions, and having but two main elements—a cathode or source of electrons, and an anode whose potential supplies the proper acceleration and direction for those electrons.

Besides dissimilarity in size, the Electron Microscope differs from the ordinary vacuum tube in many other ways. The interior of the Electron Microscope must, of necessity, be exposed to atmosphere from time to time. On the other hand, an ordinary vacuum tube is permanently sealed, and thus, conditions are ideal for obtaining and maintaining very low pressures. Outgassing of the elements and interior walls through heat, the use of "getters" (gas absorbers) and other processes tends to produce and maintain the excellent vacuum required by ordinary vacuum tubes for their applications.

The Electron Microscope has to be outgassed each time it is exposed to atmosphere, and the outgassing process becomes longer, the greater the exposure time. This is because the inner surfaces of the microscope absorb gases until saturation is reached and equilibrium is established with the surrounding atmosphere. Since it is not practical to employ continuous heating or "getters" to completely outgas and maintain vacuum in a system such as the Electron Microscope, another arrangement is employed—the use of high-speed pumping will not produce low pressures equal to those obtained by heating and "getters," it will produce a pressure low enough to be entirely satisfactory for the establishment and use of an electron beam. In other words, the high-speed pumping system removes gases at a faster continuous rate than the vacuum chamber can continually give them up and, in the process, produces the required vacuum.

The vacuum system of the Electron Microscope thus comprises (a) pumps for creating and maintaining the required vacuum within the microscope body or chamber, and (b) vacuum indicators or gauges which indicate when the internal pressure has reached a sufficiently low value to allow actual operation of the equipment. These are described in the following paragraphs. A general schematic layout of the entire vacuum system is given in Figures 6A, 6B, which shows the pumps, valves and gauges with indication of their respective implied functions:

Pumps—As described in the preceding sections, the main body of the microscope constitutes, essentially, a large vacuum tube. It is, however, constructed in a number of sections sealed with rubber gaskets which form a vacuum seal. Furthermore, as the openings through the centers of some of the sections are extremely minute, a

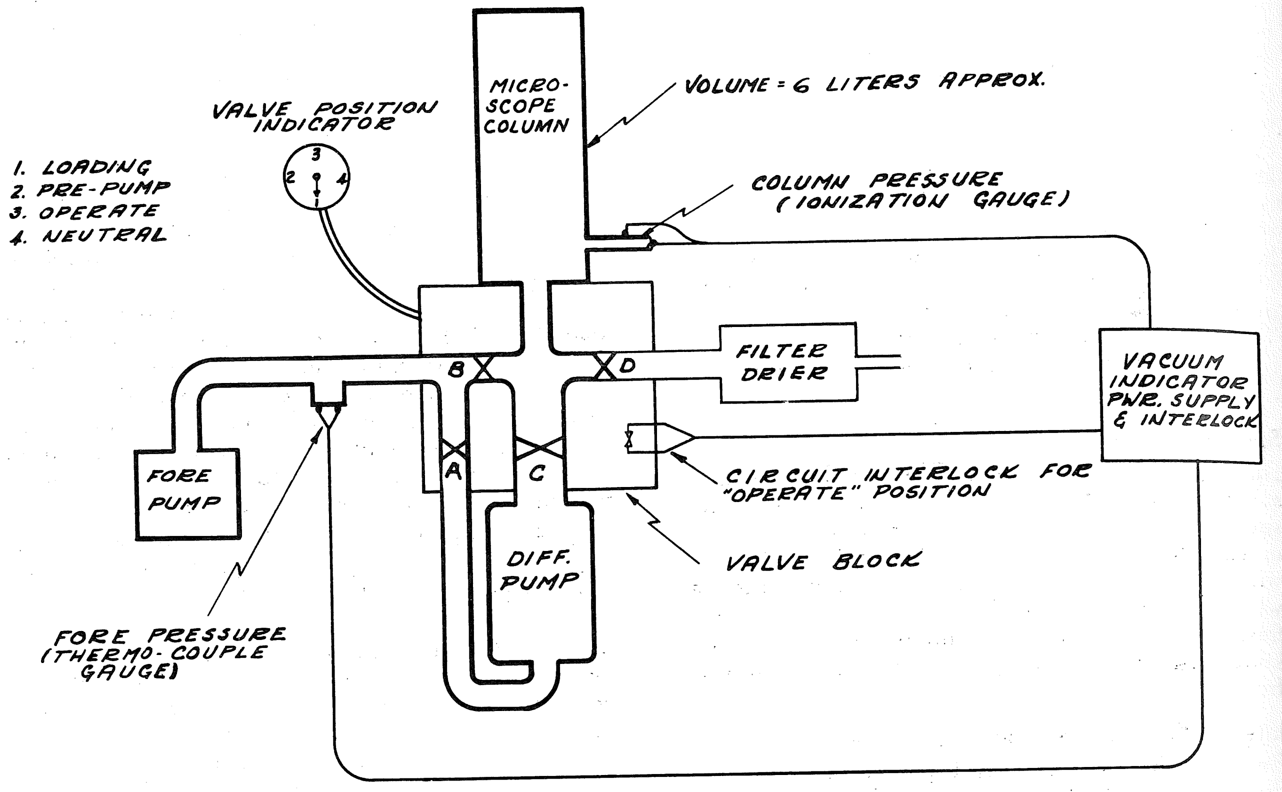

VALVE POSITION INDICATOR
1. LOADING
2. PRE-PUMP
3. OPERATE
4. NEUTRAL
MICRO-SCOPE COLUMN
VOLUME = 6 LITERS APPROX.
COLUMN PRESSURE (IONIZATION GAUGE)
FILTER DRIER
VACUUM INDICATOR PWR. SUPPLY & INTERLOCK
B
D
A
C
FORE PUMP
CIRCUIT INTERLOCK FOR "OPERATE" POSITION
DIFF. PUMP
VALVE BLOCK
FORE PRESSURE (THERMO-COUPLE GAUGE)

Figure 6A—Vacuum System, Schematic Layout (*M*-430516)

manifold is incorporated in the design to by-pass these small orifices. This is essentially a long, flexible tube with separate connections to the main chambers of the microscope body. The larger volumes of the microscope can thus be pumped out very quickly through the manifold. Incorporated in the diffusion pump is an aquastat which automatically disconnects the heater when an insufficiency in the water supply becomes inadequate for cooling. The outlet of the diffusion pump is connected by means of a flexible rubber hose to a mechanical fore pump.

With the mechanical fore pump in series with an oil diffusion pump, it is possible to obtain a vacuum of 10^{-4} mm. of mercury or better. The pumps are controlled by a valve block which opens and closes the valves in the proper sequence. This is operated by a crank on the right-hand side of the instrument, the position of which is shown on a dial on the front panel. The fore pressure and column pressure are indicated by meters on the control panel.

Fore Pump—The mechanical fore pump which is supplied with the microscope is a Cenco Hypervac 20, driven by a ½ H. P. motor. When the pump is put into operation, the motor draws a heavy starting current—18 to 20 amps.—but the normal operating current is about 7 amps. (115-volt service). The driving belt should be adjusted to the proper tension by moving the motor closer to or farther from the pump. If the belt is too loose it will slip and burn; if it is too tight it will deliver power with low efficiency. To suppress the sound of the pump, the pump may be placed in a sound-proof hood constructed of plywood lined with ozite. Figure 7 shows a satisfactory design for this hood. It is ventilated by fan blades attached to the pump motor. Holes in the hood allow the circulation of air through it.

Fore Line—The fore pump line consists of extra heavy wall rubber connecting tubing, copper pipe as required, and a glass three-way stop-cock. With this stop-cock it is possible to connect the pump to the microscope through the fore line, seal it off from the fore line, or connect it to atmosphere. This latter connection may be used either to let air into the pump or to evacuate auxiliary apparatus when the micro-

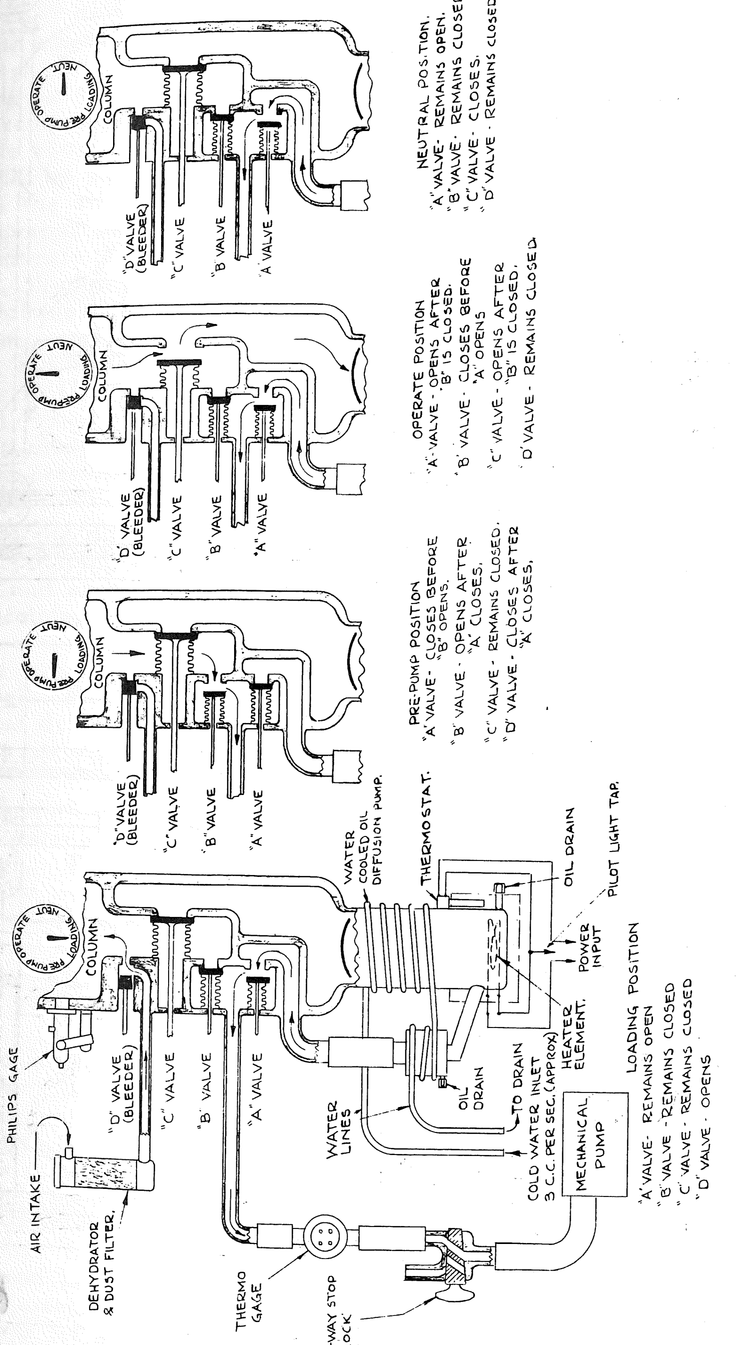

NEUTRAL POSITION.
'A' VALVE - REMAINS OPEN.
'B' VALVE - REMAINS CLOSED.
'C' VALVE - CLOSES.
'D' VALVE - REMAINS CLOSED.
OPERATE POSITION.
'A' VALVE - OPENS AFTER 'B' IS CLOSED.
'B' VALVE - CLOSES BEFORE 'A' OPENS.
'C' VALVE - OPENS AFTER 'B' IS CLOSED.
'D' VALVE - REMAINS CLOSED.
PRE-PUMP POSITION.
'A' VALVE - CLOSES BEFORE 'B' OPENS.
'B' VALVE - OPENS AFTER 'A' CLOSES.
'C' VALVE - REMAINS CLOSED.
'D' VALVE - CLOSES AFTER 'A' CLOSES.
LOADING POSITION
'A' VALVE - REMAINS OPEN
'B' VALVE - REMAINS CLOSED
'C' VALVE - REMAINS CLOSED
'D' VALVE - OPENS
NEUT. OPERATE PRE-PUMP LOADING
COLUMN
'D' VALVE (BLEEDER)
'C' VALVE
'B' VALVE
'A' VALVE
WATER COOLED OIL DIFFUSION PUMP.
THERMOSTAT.
OIL DRAIN
PILOT LIGHT TAP.
POWER INPUT
HEATER ELEMENT.
OIL DRAIN
TO DRAIN
COLD WATER INLET 3 C.C. PER SEC. (APPROX)
MECHANICAL PUMP
WATER LINES
PHILIPS GAGE
AIR INTAKE
DEHYDRATOR & DUST FILTER.
THERMO GAGE
3-WAY STOP COCK

Figure 6B—Schematic of Vacuum System (*M*-427490)

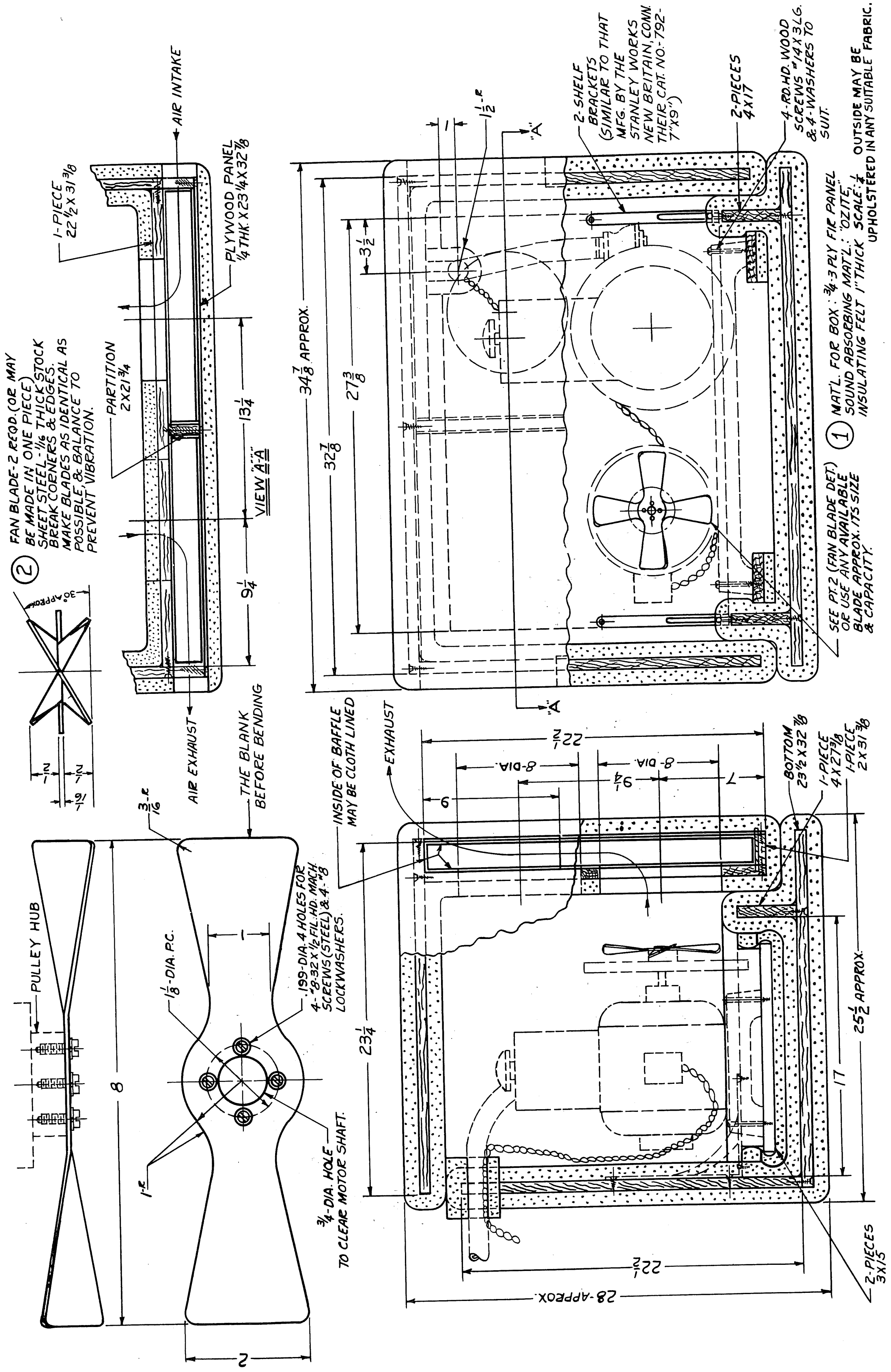

AIR INTAKE
1-PIECE 22½ X 31 3/16
PLYWOOD PANEL ¼ THK X 23¼ X 32 7/8
② FAN BLADE-2 REQD. (OR MAY BE MADE IN ONE PIECE) SHEET STEEL-1/16 THICK STOCK BREAK CORNERS & EDGES. MAKE BLADES AS IDENTICAL AS POSSIBLE & BALANCE TO PREVENT VIBRATION.
30° APPROX.
PARTITION 2X21¾
VIEW A-A
13¼
9¼
AIR EXHAUST
THE BLANK BEFORE BENDING
3/16
PULLEY HUB
1 1/8-DIA. P.C.
.199-DIA 4 HOLES FOR 4-#8-32 X ½ FIL. HD. MACH SCREWS (STEEL) & 4-#8 LOCKWASHERS
3/4-DIA. HOLE TO CLEAR MOTOR SHAFT.
8
2
INSIDE OF BAFFLE MAY BE CLOTH LINED
EXHAUST
2-SHELF BRACKETS (SIMILAR TO THAT MFG. BY THE STANLEY WORKS NEW BRITAIN, CONN. THEIR CAT. NO-792-7"X9")
2-PIECES 4X17
4-RD. HD. WOOD SCREWS #14X3 LG. & 4-WASHERS TO SUIT.
OUTSIDE MAY BE UPHOLSTERED IN ANY SUITABLE FABRIC.
① MATL. FOR BOX: ¾-3 PLY FIR PANEL SOUND ABSORBING MATL.: "OZITE" INSULATING FELT 1" THICK. SCALE: ¼
SEE PT. 2 (FAN BLADE DET.) OR USE ANY AVAILABLE BLADE APPROX. ITS SIZE & CAPACITY.
34 7/8 APPROX.
32 7/8
27 3/8
3½
A
22½
8-DIA.
9¼
7
6
BOTTOM 23½ X 32 7/8
1-PIECE 4X27 7/8
1-PIECE 2X31 3/16
23¼
25½ APPROX.
17
2-PIECES 3X15
28-APPROX.

Figure 7—Noise Suppressor for Rotary Pumps (*PX-277149*)

scope is not in operation. The stop-cock should be lubricated with a good grade of stop-cock grease. Connections in the fore line are facilitated by rubbing a small amount of castor oil on the inside of the hose. To obtain the greatest pumping speed, the conductance of the fore line should be as great as possible. Since the inside diameter of the line is fixed, pumping speed is enhanced by keeping the fore line length to an absolute minimum.

Diffusion Pump—The diffusion pump is a vertical oil pump with a metal casing. Tap water should be run through the cooling coil at a rate of 3 cc/sec, entering at the high vacuum end, 5-10° below room temperature and leaving the pump slightly above room temperature. The cooling water should be turned off when the pump is exposed to the atmosphere for a long period, since water vapor may condense inside the pump and contaminate the pump fluid. The heater is a 400-watt, 30-ohm unit which receives its power from the voltage stabilizer. A variable (R-112) resistor with screwdriver slot, located on the lower chassis, can be adjusted to vary the heater temperature. The most satisfactory heater current, about 3.0 amperes, should be set and small adjustments made to change the pumping speed or the fore pressure at which the diffusion pump will begin to operate.

If the power input to the diffusion pump is set at too high a value, pumping speed will not be materially improved and an audible "crackling" noise will be heard coming from the pump. If the slight vibrations caused by this "crackling" are imparted to the microscope column, poor micrographs will result. Resistor R-112 should be set so that the heat delivered to the pump is just below the point at which the "crackling" effect occurs.

The thermo-switch, S-15, located at the base of the pump, opens the heater circuit if the temperature becomes too high. The pump is adjusted while running normally with the proper heater current and water flow. The screw on the switch is turned until the circuit opens and then backed up one turn. The blue lamp, A-5, on the lower chassis, indicates that voltage is being applied to the heater.

An accidental inrush of air from the forepressure side of the pump may blow the pump jet assembly into the upper part of the pump. A spider prevents the jets from returning to the proper position at the bottom of the pump. It is, therefore, advisable to inspect the position and centering of the jets after sudden breaks in the fore pressure. To center the jets, direct a flashlight into the casing and bend the arms of the spider on top of the assembly until the clearance between the lower jet and the casing appears to be the same on all sides.

Valve Block—Four pump line valves, located in the valve block, are arranged so that the valves are operated in the proper sequence. Mechanical means prevent valving from being accomplished in the wrong direction. The operation of the valve block can be best understood from the block diagram of the vacuum system. (Figures 6A, 6B.)

The valve "A" connects the fore pump to the output of the diffusion pump; the valve "B" connects the fore pump to the microscope column; the valve "C" connects the intake of the diffusion pump to the microscope column; the valve "D" connects the column through the dehydrator (filter drier) to the atmosphere.

When the valve block is put in the "loading" position, "D" is open, letting air into the column; "B" and "C" are closed, sealing the microscope column off from the pumps; "A" is open so that the fore pump is pumping the diffusion pump. When the valve block is in "pre-pump," "A" closes and "C" remains closed, thereby sealing off the diffusion pump; "D" closes and "B" opens so that the fore pump can rough pump the column. In "operate" position, "D" remains closed; "B" closes, shutting the column off from the fore pump; "A" and "C" open, so that the forepump and diffusion pump are pumping the microscope column in series. In "neutral" the valve "C" is closed, so that the column is shut off from the pumps.

The valve positions are changed by one clockwise rotation of the crank handle on the right-hand side of the microscope below the cassette chamber. Valve position is indicated by the pointer and dial opposite the clock. When the indicator is installed, the pointer must be adjusted by turning the knurled knob on the back of the indicator dial so that the dial agrees with the valve position existing at the time.

The pumps should be started with the valves in "neutral" or "loading." The power to the diffusion pump can be turned on at the same time, as it will take about fifteen minutes to heat up. As soon as the fore pump has started, the stop-cock is turned so the fore pump is pumping on the diffusion pump. After about five minutes, the valve block is turned to "pre-pump." It is left in this position until the fore pressure has reached a value of 50 microns, as indicated by a half-scale reading on the fore pressure meter. It is then turned to "operate." The operating pressure of 10^{-4} mm. of mercury is indicated by a reading of 0.3 on the column pressure meter as the current is decreasing. The glow tube above the meter is lighted on both sides when the current is increasing and on one side only if the current is decreasing.

When the microscope is in use, the pumps are run continuously, and the valve block kept in "operate" except when a specimen or plate is changed. It is turned through "neutral" to "load," to let air into the column.

When the microscope column is repumped, the forepressure must be brought down to 50 microns at "prepump" before the valve block is turned to "operate." It should be possible to pump the instrument from atmospheric to operating pressure in about one and a half minutes. When the instrument is shut down for the night, or extended periods, the valves are left in "neutral," sealing off the column. The pumps are turned off. The stop-cock in the fore line is always closed before the fore pump is turned off.

Vacuum Gauges—The microscope contains two pressure gauges which are read on the two meters on the left-hand side of the control panel. The power to the gauges is supplied by transformers, T-5 and T-9, which are wired so that the gauges will operate if either the "main power" or the "panel lights" are turned "on." The gauge circuits are described in the section on electrical circuits.

The fore pressure is measured by a thermocouple gauge located in the fore line between the stop-cock and the valve block. As the pressure is decreased, the energy radiated by the hot thermocouple is decreased, its temperature is increased, and the thermo-electric voltage and the meter reading are increased. The fore pressure meter is calibrated by adjusting R-14, on the back of the control panel until the meter M-1 reads full scale at the minimum pressure obtainable when the fore pump alone is pumping on a system free of leaks.

The column pressure is measured by a cold cathode ionization gauge located at the base of the microscope column. The gauge is a two-element tube passing a current which depends on the amount of ionization in the column. This amount of ionization is a function of pressure. The current is measured by the meter M-2 and is roughly indicated by the glow tube, V-9. As the pressure is decreased, the current rises to a maximum and then falls to about zero.

The column pressure meter is calibrated by adjusting R-12 on the back of the control panel in such a manner that when the pressure is decreased, and the meter indication rises to a maximum, and then falls back toward zero, the maximum reading will be approximately full scale.

The ionization gauge circuit is designed to close the relay, K-1, when the current falls to a value corresponding to the maximum safe operating pressure of the microscope. The relay closes the high voltage and electron gun filament circuits. If the column pressure should accidentally rise above operating pressure, the high voltage and gun circuits are automatically opened. The relay cannot operate at low ionization currents corresponding to near atmospheric pressures, because it is shorted by an interlock switch. However, this is not the case when the valves are in "operate" position.

Filter Drier—The air which is let into the column is dried and cleaned by passing it through the air filter which is located in the right-hand side of the microscope cabinet. The cleaning is accomplished by the felt pads at the ends of the filter. About once a year these should be cleaned thoroughly with a blast of air or replaced. The air is dried with "Indicating Drierite" or anhydrous calcium sulfate. If the dehydrated Drierite becomes rose colored up to the "change line," it should be replaced by dry Drierite or the pump down time of the microscope will increase because the Drierite is saturated with water vapor which can be drawn into the column. The Drierite can be regenerated by heating in an open pan in an oven or on a hot plate, at a temperature of from 200°C to 250°C from one to two hours. The Drierite should at no time be heated above 300°C (572°F). The Drierite should be agitated during the heating process because water is released from the upper surface.

CONTROL PANEL

The functions of the controls mounted on the control panel are described in accordance with the titles as engraved on the control panel.

1. **PANEL LIGHTS**—A toggle (S-3) switch supplies power to the panel lights and to the vacuum gauges and their circuits. When extreme darkness is required for image examinations, switch S-3 turns off panel illumination. The switch is interlocked with the main power switch. If the main power switch is "on" the panel lights can be turned off, but the power to the vacuum gauges and their circuits will remain "on."

When the panel lights, main power, and high voltage switches are thrown to the left, they are in the "off" position.

2. **MAIN POWER**—Through the main power switch (S-4), power is supplied to the low-voltage supplies and the vacuum gauge circuits. To operate the microscope the main power switch is thrown to the "on" position and the test meter switch is set to the "Proj" position. When the test meter has stabilized at a reading of approximately 60 (150 milliamperes actual current), all circuits have warmed up and the high-voltage switch may be turned on.

3. **HIGH VOLTAGE**—The high-voltage switch (S-8) controls the circuits which produce the 50 kv accelerated voltage. However, 50 kv can not be obtained unless the following conditions are satisfied; the main cabinet door interlocks are closed; the main power switch is closed; the cabinet hood interlock switch is closed; the valving system is in the "Operate" position; and the electronic circuits of the vacuum gauges indicate that a sufficiently low pressure has been reached in the microscope column.

4. **ROOM LIGHTS**—The room light switch is connected to a 3-way receptacle inside the cabinet. This receptacle may be tied in with a portion of the lower room lighting and a 3-way wall switch, allowing room illumination to be controlled either from the control panel of the microscope or from the wall switch.

5. **DIFFRACTION-PROJ. SWITCH**—With this switch in the "Diff" position, the diffraction lens is operative and the current through the lens is controlled by the "Diff Focus" control. In the "off" position neither the diffraction or projection lenses are actuated. With the switch in the "Proj" position, the "magnification" control regulates the current in the projection lenses.

6. **OBJ. SWITCH**—In the "off" position, no current is fed to the objective lens. In the "on" position, the three focusing controls, Nos. 1, 2 and 3, regulate the current in the objective lens.

7. **COND. SWITCH**—In the "off" position, this switch removes current from the condensing lens. In the "on" position, it allows the "Intensity" control to regulate the current of the condensing lens.

8. **TEST SWITCH**—The test switch and its associated meter allow instantaneous checking of all the important voltages and currents in the electronic circuits.

Other controls, such as the camera cassette and shutter, specimen movement, vacuum gauges, gun filament and "beam" meter, are described in other portions of these instructions relating to the specific equipment.

POWER SUPPLY SYSTEM

WARNING: Many of the voltages used throughout the circuits of the microscope are dangerous to life. Circuit checking and trouble shooting should be performed by no fewer than two operators. Even though power has been turned off, various capacitors in these circuits are capable of storing electrical energy for considerable periods of time, at voltages which are dangerous to life. Before touching anv of these circuits, they should be grounded and discharged with the "grounding rod" supplied as a part of the equipment. Tapped holes are provided on both sides of the cabinet frame where the grounding rod conductor may be securely fastened. In addition to grounding, it is good practice to test each circuit requiring examination with a voltmeter before any physical contact is made.

In order to prevent damage to the equipment, tubes should not be removed from circuits in operation. Before putting the electrical circuits into operation, the following instructions should be read carefully. Likewise, the warning given on labels on the inside of both cabinet doors should be understood.

Function of the Power Supply

It is a function of the power supply system to provide from the 115-volt, 60-cycle supply line, the various alternating and continuous voltages required for the operation of the electron microscope and its associated equipment. At the same time, the electronic system insures the necessary high degree of constancy of these operating voltages.

All input power for the microscope, with the exception of the vacuum fore pump, is obtained from the voltage stabilizer. Changes in line voltage between the ranges of 95 to 130 volts are regulated to 115 volts by the line voltage stabilizer.

Location of Power Supplies

The main portion of the cabinet is divided into three sections, which permits easy access to the electronic circuits and components. The top section, containing the high-voltage unit, provides the accelerating voltage of 50 kv for the electron beam. The middle section, comprising the upper chassis, contains the required oscillators and their components. The lower section, or bottom chassis, includes the main sources of d-c power and the vacuum control circuits. The instrument control circuits are mounted on the control panel at the front of the instrument. Access to the high voltage, upper and lower chassis is obtained through the main cabinet doors. To gain access to the control panel, it is simply necessary to slide the table top forward and remove it. With the table top removed, the control panel can be tilted or disconnected and removed from the instrument for servicing.

The drawings included in this instruction book which describe the electronic circuits are as follows: block diagram Figure 8, overall schematic Figure 71.

CIRCUIT DESCRIPTION

BLOCK A—+370-volt regulator rectifier and projector regulator plate supply rectifier. Block A consists of tubes V-3, V-4, V-5, V-6, V-7 and V-8, transformer T-3 and their associated components.

The function of Block A is to provide a regulated d-c voltage of 370 volts and an unregulated d-c voltage of 400 volts, both positive with respect to ground. The regulated voltage is used as plate supply for tubes in Block E (the electron gun filament oscillator), block K (the high-voltage regulator), Block B (the projector regulator and supply) Block C (the objective regulator and supply), and in Block D (the condenser supply). The unregulated voltage is provided as a source voltage for Block B. Block A receives its power from the transformer, T-3, which has windings of 500 volts, 5 volts and 6.3 volts, and from sections No. 3 and No. 7 of T-4. The plates of both of the full wave rectifier tubes, V-3 and V-4, are supplied by the 500-volt winding of transformer T-3. The filament of V-3 is heated by the 5-volt winding of transformer T-4. The filament of Tube V-4 is heated by the 6.3 volts winding of T-3. The resistor, R-1, is placed in the circuit to drop the voltage for the filament of tube V-4 to 5 volts. The filaments of tubes V-7 and V-8 are heated in parallel by section No. 3 of transformer T-4 and that of tube V-6 is heated by section No. 7 of T-4.

The rectified voltage across tube V-4 is filtered by chokes L-4, L-5, and capacitors C-6, C-7, C-10 and C-11. The output, an unregulated voltage of 400 volts, is applied to the anode of tube V-14 in Block B.

The rectified voltage across tube V-3 is filtered by choke L-3 and capacitors C-4, C-5, C-8 and C-9, and fed through variable resistance tubes, V-7 and V-8, to the output capacitor, C-14. Re-

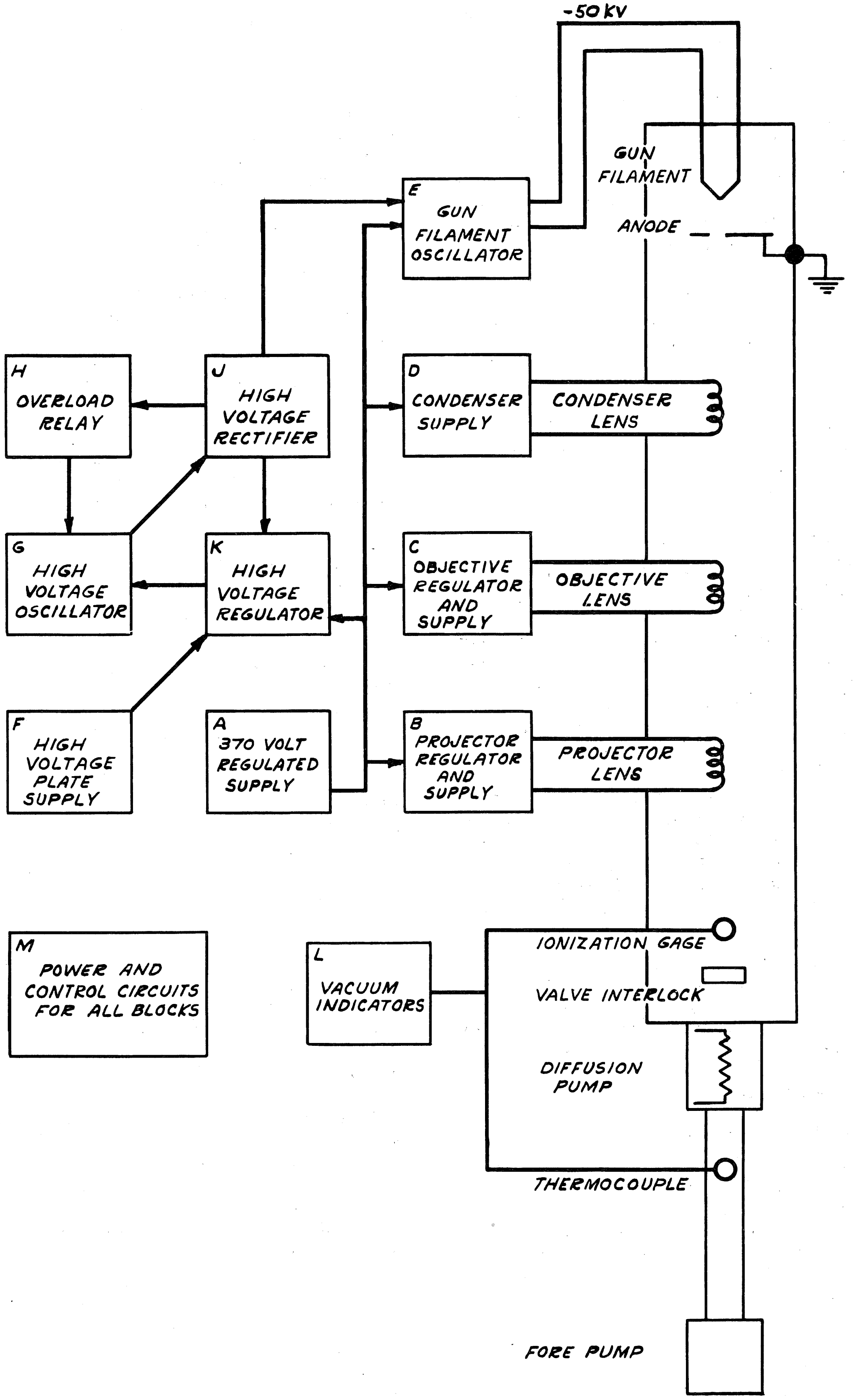


Figure 8—Electrical Block Diagram of Electron Microscope (M-427474)

sistors R-2 and R-8 constitute a voltage divider across the output, and part of the output voltage is coupled through resistor R-4 to the grid of tube V-6. The a-c coupling from the output to this grid is provided by capacitor C-13. The cathode of tube V-6 is maintained at a constant potential relative to ground by V-5, a constant voltage tube, in parallel with capacitor C-12. Since tube V-6 will not pass enough current to keep tube V-5 fired, an additional path for current is provided by resistors R-3 and R-62.

The output voltage of the rectifier tube, V-3, is applied as a positive potential to the anodes of tubes V-7 and V-8. The screens of these tubes are connected to the same voltage supply through dropping resistors R-6 and R-7. This tube, V-3, also supplies a positive voltage, through resistor R-5 to the anode of tube V-6. The grids of tubes V-7 and V-8 are connected in parallel and are decoupled by resistor R-9.

If the load on the regulator draws an increased current, the output voltage across capacitor C-14 will tend to decrease. This decreased output voltage will bias the grid of V-6 more negatively, causing a decrease in plate current and a rise in anode voltage. This potential increase in a positive direction is transmitted to the grids of V-7 and V-8 and allows them to pass more current. The increased current will flow through the voltage divider, raising the voltage across it and C-14. Thus the original drop in voltage, caused by the load, is compensated and the voltage is kept at a constant value.

This regulated voltage of 370 volts can be measured on the control panel test meter by turning the switch to "Reg." This connects the meter in series with the multiplier, R-72, converting it into a 1,000-volt full-scale voltmeter.

BLOCK B—Projector regulator and supply. This block consists of tubes V-14 and V-16, the proj.-diff. lens and the associated components and controls.

The function of Block B is to maintain a steady current through the projection or diffraction lens windings and the heaters of tubes V-16, V-22, and V-24. V-16 is part of Block B; V-24 is in Block C, the objective regulator and supply; and V-22 is in Block K, the high-voltage regulator. These filaments are heated by a regulated current in order to keep the emission of the cathodes uniform and enhance the regulating characteristics of their circuits. The current through the projection and diffraction lenses must be constant to keep the magnification constant.

Switch S-7, located on the control panel, will put either the projection coil or the diffraction coil in series with the heaters of V-16, V-22 and V-24 as the load on the regulator. In its "off" position, both coils are disconnected but the heaters continue to draw current. The projection coil is paralleled by resistors R-100, R-101, R-102, R-103, R-104, R-105, R-106, R-107, R-108, R-109, R-110, R-111, and R-114. The "Magnification" dial S-14 on the control panel is a selector switch which changes the current through the projection coil by changing the interconnections of the above mentioned resistors. Resistor R-100 keeps the oil from being shorted on the position of lowest magnification. The diffraction coil is paralleled by Resistors R-24 and R-25. R-25, the "Diffraction focus" dial on the control panel, is a variable resistor which allows adjustment of the current through the coil. Resistor R-24 is shunted across the diffraction coil to prevent it from being shorted. The diffraction coil, with a resistance of 280 ohms, has in series with it resistor R-23. The combined resistances of the coil and the resistor offer approximately the same resistance to the regulator as the 634 ohms resistance of the projection coil.

A suitable load reference voltage for the input of the regulator tube, V-16, is developed across the resistors R-34 and R-17 in series with the load. R-34 can be adjusted to determine the operating current of the regulator. Capacitor C-17 provides the AC coupling from the load to the grid of tube V-16. The reference grid bias for V-16 is obtained from B-10 (45 volts) in series with the decoupling resistor, R-33, and the fuse, F-6, which protects the battery in case of shorts. The anode voltage of tube V-16 is obtained through the voltage-dropping resistor, R-28, from the 370 volts regulated supply of Block A. The anode voltage of tube V-14 is obtained from the 400-volt unregulated supply of block A. The screen and cathode of V-14 are kept at lower potentials than the anode by R-30 and R-31, respectively. The filament of tube V-14 is heated by section #4 of transformer T-4. Resistor R-32, which is in series with the load, is adjusted in conjunction with resistor R-34 to provide regulation of the output circuit at its rated value of 150 ma. This value is correct for the heaters of tubes V-16, V-22 and V-24, as well as the lens regulation circuits.

An increase in load current makes the control grid of tube V-16 more positive and the anode more negative. When the current through tube V-16 increases, the grid of tube V-14 becomes more negative, the tube passes less current and the load current returns to its normal value. The regulated current through the load is measured by turning the test meter switch to "Proj." This connects the meter in series with the load, and shunts it with R-29, making it a 250 ma. full scale milliammeter.

BLOCK C—Objective Regulator and Supply. Block C includes tubes V-23 and V-24, the objective lens, and the associated components and controls.

The function of block C is to maintain a steady current through the objective lens coil which has a resistance of 2630 ohms. S-12 is the objective switch on the control panel. In "off" position, the objective coil is shorted and the resistor, R-66, is substituted for it so as not to upset the stability of the regulator when the switch is turned "off" and "on." When the switch is "on," the lens coil is connected in series with resistors R-74 to R-93 inclusive. This resistance network is the coarse control of the objective current used to focus the image, and is adjusted by the "focus 1" dial on the control panel. Resistors R-64, R-19, and R-63 are in parallel with the above mentioned series resistor network. R-64 is the "focus 2" or medium control and R-19 is the "focus 3" or fine control. R-63 is a fixed resistor which keeps either branch of the focus control resistor networks from shorting the other. The reference grid bias on the control grid of the regulator input tube, V-24, is obtained from the battery B-11. The decoupling resistor, R-60, and the fuse, F-5, are connected in series with the battery in order to protect the circuit in case of short circuits. AC coupling to the control grid is provided by capacitor C-42. The anode of the series regulator tube, V-23, is supplied directly by the 370 volt regulated output of block A. The screen grid of V-23 is supplied through resistor R-56; the control grid of tube V-23 and the plate of the tube V-24, are supplied through resistor, R-58. The filament of tube V-23 is heated by section 5 of the transformer T-4, and that of the tube V-24 by block B.

When the current through the objective coil increases, the voltage on the grid of the tube V-24, becoming more positive, causes it to draw more current. The voltage on the plate of the tube V-24 and the grid of V-23 decreases. The tube V-23, therefore, passes a lower current through the load, compensating for the original increase. The regulated current is measured by turning the test meter switch to "obj." which connects the meter across resistor R-61. The meter then becomes a 250 ma. full scale milliammeter in series with the objective coil.

BLOCK D—Condenser Supply.—Block D consists of the condenser lens and its associated controls.

The function of block D is to supply a regulated current at some chosen value through the condenser lens coil, having a resistance of 9440 ohms. In the "off" position of the condenser switch, S-5, the condenser coil is shorted; in the "on" position of the switch S-5, the coil is connected through rheostat, R-21; to the 370-volt regulated supply of block A. The movable tap is used to adjust the current through the condenser coil by changing the resistance in series with it. This is the "intensity" dial on the control panel. The current, limited by resistor R-22, is measured by turning the test meter switch to "cond." The test meter, in series with the load and with R-61 shunting it, is converted into a 25 ma. full scale milliammeter.

BLOCK E—Gun Filament Oscillator. — This block consists of tube V-27, transformer T-10 and the associated controls and components.

The function of block E is to heat the electron gun filament. An alternating current source of about 185 KC transfers power to the filament circuit by inductive coupling. It thus isolates the supply source from the high d-c voltage on the gun filament. Insulation is thereby simplified and the number of points at which high voltage has to appear are reduced.

The RF voltage to supply the filament is generated by a Colpitts oscillator, tube V-27. The anode is supplied through the choke coil L-10 and resistor R-70 from the 370-volt regulated supply of block A. This voltage is disconnected by the vacuum interlock of block L if the pressure in the column is not low enough to operate the microscope. Resistor R-70, marked "gun filament" dial on the control panel, controls the output of the oscillator by changing the plate voltage. The choke L-10 and capacitor C-39 prevent RF current from being fed into the plate supply. Capacitor C-38 is a by-pass condenser for the screen grid resistor R-69.

The cathode is grounded through resistor R-68, a test meter shunt. When the meter switch is turned to "Fil," the meter connected across resistor R-68, becomes a 250 ma. full scale milliammeter which reads the anode current of the oscillator. Capacitor C-37 by-passes the RF current from the meter. The heater of the oscillator tube is supplied by transformer T-8.

The power is transferred to the gun filament by the transformer T-10. A grounded electrostatic shield prevents the secondary of the transformer T-10 from picking up voltages from the 75 KC high voltage oscillator or from other stray fields. The resistors, R-44 and R-45, form a balanced network for the gun filament. Resistor R-43 is a surge resistor which protects the high voltage rectifiers in case of an overload in the microscope.

BLOCK F—High Voltage Oscillator Plate Rectifier.—This block contains the rectifier tubes V-1 and V-2, the transformers T-1 and T-2 and the associated filter circuit.

The function of block F is to supply the DC voltage for the plates of the oscillator tubes of the high voltage oscillator, block G. The power for block F is supplied by the transformer, T-1, which has a secondary voltage of 1180 volts and transformer, T-2, which has a secondary voltage of 5 volts. The filaments of the tubes V-1 and V-2 are heated by the transformer T-2. The rectified voltage is filtered by the chokes L-1 and L-2, and the capacitors C-1, C-2, and C-3. The 1250-volt d-c output of the rectifier tube is fed to the plates of the tubes V-15, V-17, and V-20 in block K, the high voltage regulator, and to the plates of the tubes V-18 and V-19 in block G, the high voltage oscillator.

BLOCK G—High Voltage Oscillator.—Block G includes the tubes V-18 and V-19, oscillator transformer L-8 and related circuit components.

The function of block G is to provide a high alternating voltage which is rectified and applied to the gun filament to establish the electron beam. The voltage is generated at 75 KC by a modified form of Hartley oscillator in which the output is taken from the coil of a series resonant circuit in series with the oscillator coil.

The two oscillator tubes, V-18 and V-19, are connected in parallel. R-39 is the decoupling resistor between the grids and R-38 is the decoupling resistor between the plates. The d-c plate voltage is supplied by block F through the resistor, R-95, in block K, the high voltage regulator circuit. The choke L-9 and the capacitor, C-22, keep the RF current out of the d-c supply. The resistor R-37 is a multiplier to convert the test meter into a 1000-volt voltmeter. When the meter switch is on "OSC. Voltage" it measures the d-c plate voltage on the oscillator tubes. The filaments of the tubes, V-18 and V-19, are heated by the transformer T-7. The capacitors, C-18 and C-19, by-pass the RF current around the transformer T-7 which would otherwise present a high impedance. The grid bias is obtained from current through the resistor R-41, by-passed by the capacitor C-21 to prevent negative feedback. The resistor, R-40, is a meter shunt to convert the test meter into a 250 ma. milliammeter. When the meter switch is on "OSC. Current" it measures the d-c anode current of the oscillator. C-20 by-passes the RF current from the meter. One end of the feedback coil, L-8, is connected to the grid through the capacitor C-21. The other end is grounded through the capacitor C-20. The tap of the coil, L-8, is connected to the center tap of the filament transformer, T-7. When an overload occurs, this point is grounded by the relay, and oscillation ceases. The return circuit from ground to the plate is through block J, the high voltage rectifier. To the oscillator, the equivalent circuit of block J is that of a series resonant circuit, resonant at 75 KC. About 17,000 volts appear across the coil, L-13, the coil of the series resonant circuit in block J.

BLOCK H—Overload Relay—This block includes relay K-2, meter M-3, tubes V-25 and V-26 and associated circuit parts.

By automatically turning off the high voltage, block H protects various circuits when the beam current becomes too high. If the current exceeds one milliampere the relay will short part of the feedback coil of the high voltage oscillator and stop oscillation.

In normal operation, the return path of the beam current from ground to block J, the high voltage rectifier, is through the relay, K-2; meter M-3; and resistors, R-54 and R-55. The meter M-3 on the control is the beam current meter panel. When on the control the beam current becomes excessive, the voltage across the resistor, R-54, fires the tube, V-26, which carries most of the current and protects the meter. The resistor, R-55, is a surge resistor to distribute the voltage in case of a sudden overload. The resistors, R-56 and R-57, provide a path in parallel with the relay K-2. The resistors R-42 and R-53 provide a locking path for the relay, if it is operated. The capacitor C-36 and the resistor R-56 protect the relay contacts.

When the beam current is high enough to operate the relay, K-2, the relay grounds the center tap of the feedback coil (L-8) of the high voltage oscillator tube.

The relay also connects the tube V-25 and resistor R-56 in series, the resistors R-42 and R-53 across the plate supply of the high voltage oscillator, causing the tube V-25 to fire. The tube V-25 is the overload indicator on the control panel. Current also flows through the resistor R-57, to hold relay K-2 in its overload position. This current will keep the relay in its overload position after the beam current has been turned off. The relay returns to its normal position when the high voltage switch (S-8) is turned off.

BLOCK J—High Voltage Rectifier and Tripler—This block includes tubes V-28, V-29 and V-30, transformers L-13, T-12 and T-13 and required circuit components.

The function of Block J is to maintain a negative d-c voltage of 50,000 volts with respect to ground on the electron gun filament. The anode of the microscope, which is grounded, can then accelerate the electrons emitted by the filament. The r-f voltage from Block G, the high-voltage oscillator, is rectified and tripled by Block J.

An r-f voltage of approximately 17,000 volts appears across coil L-13. C-44 is a coupling condenser to the oscillator, Block G. The filament of the tube V-28 is heated by the transformer T-4. It is put at ground potential for high frequencies by the capacitor C-31, which also by-passes r-f from the overload relay system. The filaments of the tubes V-29 and V-30 are heated by the transformers T-12 and T-13.

When the plate of V-29 receives a positive voltage from the transformer L-13, it conducts, charging the capacitor C-30. On the next half cycle, the voltage across the coil L-13 and the voltage across the capacitor C-30 are in series and the plate of the tube V-28 is positive. When the tube V-28 conducts, it discharges the capacitor C-30 and charges the capacitors C-26 and C-27 in series to the sum of the voltage across the coil, L-13 and the capacitor, C-30. In the next half cycle, the tube, V-29, conducts, recharging the capacitor C-30. At the same time the tube V-30 conducts charging the capacitor, C-28. (For simplicity of description, the operation of V-30 up to this point has been omitted.) The voltage across the capacitor C-28 is in series with that across the capacitors C-26 and C-27, so that after several cycles, the capacitor C-29 is charged to 50,000 volts, the sum of the voltages across the capacitors C-26, C-27 and C-28. The negative high voltage is connected to the gun filament by the surge resistor, R-43. The bleeder resistor, R-65, in series with the resistor R-52, acts as a voltage divider across the high voltage. The voltage across the resistor R-52 is applied to the grid of the tube V-22 in Block K, which regulates the high voltage. The coil L-15, and the capacitors C-29, C-23 and C-24 constitute a wave trap for the ripple frequency of the high voltage. They constitute a series resonant circuit which presents a low impedance to 75 kc. and by-passes it from the load, the microscope. When either of the side doors is opened, the capacitors C-26, C-27, C-28, C-29 and C-30 are mechanically grounded and discharged.

BLOCK K—High Voltage Regulator Circuit—This block includes the tubes V-15, V-17, V-20, V-21 and V-22 and their associated circuit components.

The function of Block K is to regulate the high voltage. When the beam current increases, it tends to make the high voltage decrease. Block K increases the plate voltage of the high-voltage oscillator tubes in Block J, the high voltage increases and is restored to its normal value.

The plate voltages of the series regulator tubes, V-17 and V-15, are obtained from the 1,250-volt output of Block F, the high-voltage plate supply rectifier. The control grid voltage of the tube V-17 is also obtained from the above mentioned plate supply through the voltage dropping resistor, R-35. The screen grid voltage of V-17 is obtained from a tap on the resistor R-95. The grid of the tube V-15, which is connected to the anode of the tube V-17, is biased by the resistor R-36. R-15, R-96 and R-97 are decoupling resistors to prevent parasitic oscillations. The filaments of the tubes V-17 and V-15 are heated in parallel by section No. 2 of the transformer T-4.

The plate voltage of the tube V-20 is obtained from the 1,250-volt supply through the resistor R-35. The screen voltage is obtained through the resistor R-46 from the 370-volt supply of Block A. The control grid of the tube V-20 and the anode of the tube V-22 are supplied through the resistor R-48 from the 370-volt supply. The cathode of the tube V-20 is maintained at constant potential by the tube V-21. Additional current is supplied through the resistors, R-46 and R-47, to keep the tube V-21 fired. The by-pass capacitors C-33 and C-34 prevent negative feedback to the screen grids of the tubes V-22 and V-20. The screen voltage of the tube V-22 is obtained from V-21 through the voltage dropping resistor, R-50. The filament of the tube V-20 is heated by section #6 of the transformer T-4. The filament of the tube V-22 is part of the load of Block B, the projector regulator supply. R-18, R-94 and R-98 are decoupling resistors. The control grid voltage of the tube V-22 is the algebraic sum of the voltages of the batteries B-1 to B-9 in series with that part of the output voltage which appears across the comparing resistor, R-52. The fuse F-4 protects the batteries and the resistor R-52 in case of overload. The resistors R-49 and R-51, and the capacitors C-32 and C-35 are filter circuits which prevent spurious oscillation in the regulating circuits.

If the beam current increases, the high voltage, and the voltage across the resistor R-52 will tend to decrease. The grid of the tube V-22 will become more positive and draw more current through the resistor R-48. The voltage on the plate of the tube V-22 decreases and the grid of the tube V-20 becomes more negative. The tube V-20 draws less current through the resistor R-35, making the anode of the tube V-20 and the grid of the tube V-17 more positive. As the tube V-17 draws more current it causes its cathode and the grid of the tube V-15 to become more positive. The tube V-15 draws more current, making its cathode more positive. This point is connected to the anodes of the tubes V-18 and V-19, in Block G, the high-voltage oscillator. This increase in plate voltage increases the amplitude of the oscillator and raises the high voltage, thus maintaining the high voltage at a constant level.

BLOCK L—Vacuum Indicators—This block includes the tubes V-9, V-10, V-11, V-12 and V-13, meters M-1 and M-2, transformer T-5 and other associated components.

The function of Block L is to indicate the pressure in the column of the microscope, the pressure in the fore pump line and to control the vacuum interlock circuits for the high voltage.

The fore pressure is indicated by the thermocouple gauge. The hot junction of the thermocouple (V-12) is located between the fore pump and the diffusion pump. The thermoelectric voltage is applied across M-1, the fore pressure indicator on the control panel. The junction is heated by the 5-volt section of the transformer T-9. The resistor, R-14, is in series with the thermocouple heater to determine the current through it and can be adjusted to make a convenient maximum reading on M-1. As the pressure in the microscope becomes lower, the amount of heat lost by the thermocouple becomes lower and its temperature becomes higher. The thermoelectric voltage increases and the reading of M-1 is higher.

The column pressure is indicated by the ionization gauge, V-13, which is located at the base of the microscope column. The gauge consists of a cathode and an anode which are located between the poles of a magnet. The magnet lengthens the path of an electron between the cathode and anode, increasing its ionization possibilities and making the gauge effective at lower pressure. The voltage to operate the gauge is supplied by the 2,150-volt transformer, T-5. M-2, the column pressure meter on the control panel, measures the ionization current. R-12 is a variable shunt resistor on the meter M-2, to adjust its maximum reading to full scale. The capacitor C-15 by-passes a-c current from the meter M-2. The resistor R-10 limits the current through ionization gauge V-13. The transformer T-6 transmits the current variations to the vacuum interlock circuit. V-9 is an auxiliary indicator on the control panel, and shows column pressure conditions as a rough check on the meter M-2.

The a-c current and the a-c component of the rectified current are transmitted by the transformer T-6, to the full wave rectifier tube V-10. The secondary voltage is applied to the cathodes of the rectifier tube V-10, and the load on the tube V-10 consists of the resistor R-16 and the capacitor C-16, which by-passes a-c current. The d-c voltage across the resistor R-16 is applied to the grid of the amplifier tube V-11. The filaments of the tubes V-11 and V-10 are heated in parallel by the 6.3-volt section of the transformer T-9. The load of the tube V-11 is the relay, K-1, and the current limiting resistor R-20, which can be adjusted to determine the pressure at which the relay operates.

When the valve block is set in "pre-pump" position, the valve interlock switch S-6 shorts the relay K-1 so that it cannot operate until the valves are in "operate" position. As the current through the transformer T-6 decreases, the negative grid bias on the tube V-11 decreases and the plate current increases. When the pressure is low enough, the current through the relay will close the high voltage and the gun filament oscillator circuits. There will also be a high anode current at pressures near atmospheric, but the relay, shorted by S-6, cannot operate under this condition.

BLOCK M—Power Supply and Control Circuits—The function of Block M is to supply power to all the blocks.

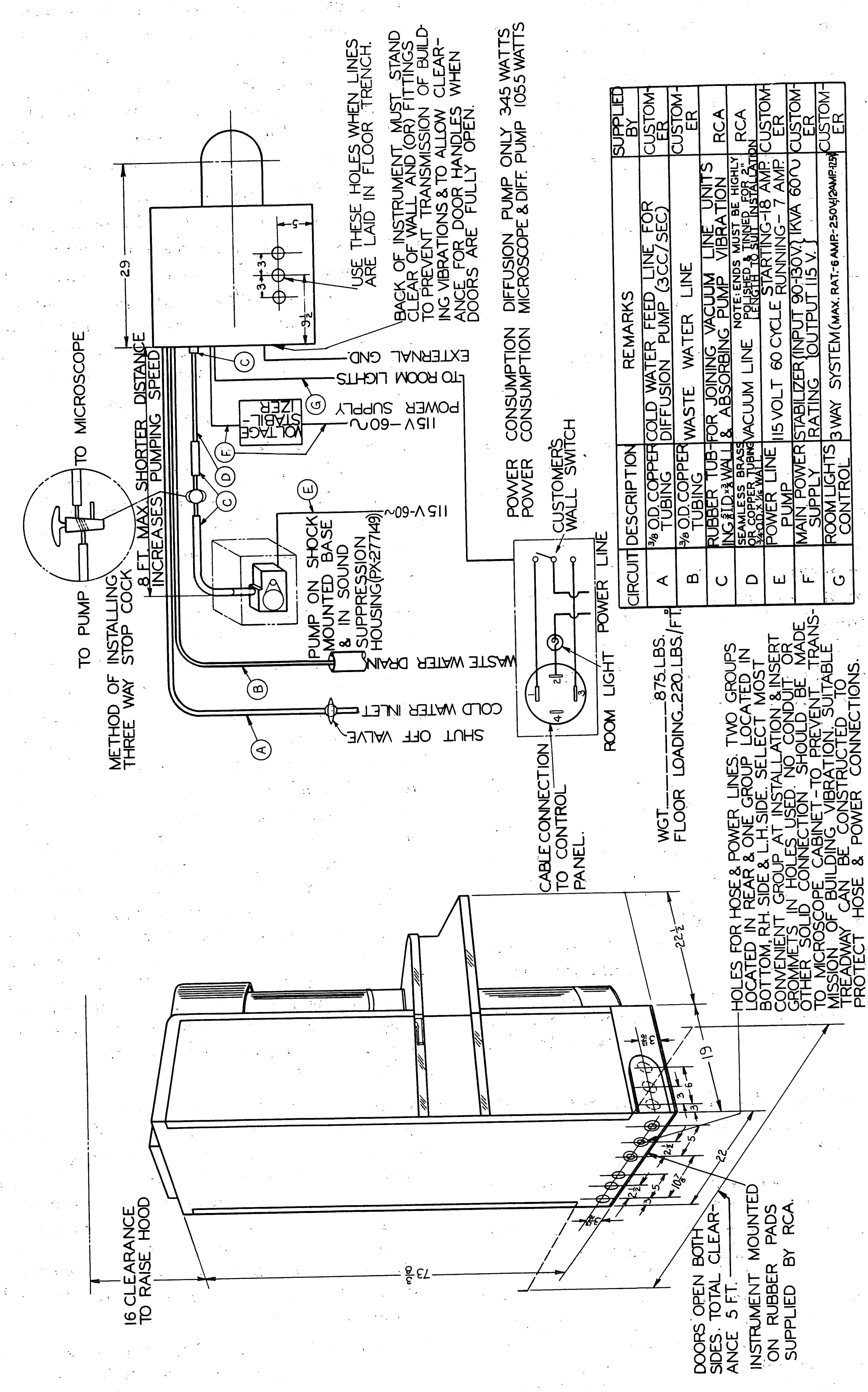
The power for the vacuum fore pump is obtained directly from the 115-volt, 60-cycle line. All other a-c power for the microscope is supplied through the voltage stabilizer transformer T-14, and the fuses F-1 and F-2. The heater of the diffusion pump in series with switch S-15 and the resistors R-112 and R-113 is connected across the output of the transformer T-14. S-15 is a thermoswitch which will open if the pump becomes too hot. The resistors R-112 and R-113 limit the current through the heater. The resistor R-112 can also be adjusted to determine the temperature of the heater for optimum pumping speed. A-5 is a lamp connected directly across the heater to indicate when voltage is applied to the diffusion pump heater. Both the fore pump and the diffusion pump operate independently of any controls on the microscope control panel.

S-1, S-2, S-17 and S-18 are interlock switches which open with the side doors of the microscope. Opening either door will turn off all exterior power to the microscope except to the fore pump and diffusion pump. Resistors R-26, R-27, R-71 and R-73 are in series with A-1, A-2, A-3 and A-4, the lights on the control panel, and drop the line voltage to the proper amount. S-3, the panel light switch, connects the lights and the transformers T-5 and T-9 across the line voltage. S-4, the main power switch, connects the transformers T-5, T-9, T-3, T-2, T-8, T-7, T-4 and T-1 across the line voltage. The transformers T-5 and T-9 supply block L, the vacuum indicators. These circuits will operate with either the panel lights or the main power turned "on."

The transformer T-3 supplies the power for Block A and is protected by F-7 in case of a short in either of the tubes V-3 or V-4. The transformer T-2 heats the filaments of the rectifier tubes in Block F. The transformer T-8 heats the filament of the oscillator tube in Block E. The transformer T-7 heats the filaments of the oscillator tubes in Block G. The transformer T-4 heats the filaments of most of the regulator tubes. The power for Block F, the high-voltage plate supply rectifier, is supplied by the transformer T-1. This transformer has three switches in series with it so that when the main power switch is turned on it will not be connected automatically. S-8 is the high-voltage switch on the control panel. S-10 is the interlock switch which opens the circuit when the top hood is raised. The third switch is controlled by the relay, K-1, and will not close unless the pressure is sufficiently low.

The test meter M-4 is a 1,000-ohm, 1-ma., d-c instrument. Its negative terminal is grounded and the positive terminal is connected to the selector switch S-11, so that it can be used to measure the current through the condenser lens, the objective lens or the projector lens, the cathode current of the gun filament oscillator or the high-voltage oscillator, the regulated voltage output of Block A, or the plate voltage of the high-voltage oscillator.

The switch S-13 is a double-throw switch which can be connected to the room lights so that they can be turned on and off from the control panel of the microscope.


TO PUMP
TO MICROSCOPE
METHOD OF INSTALLING THREE WAY STOP COCK
8 FT. MAX. SHORTER DISTANCE INCREASES PUMPING SPEED
29
3½
USE THESE HOLES WHEN LINES ARE LAID IN FLOOR TRENCH.
BACK OF INSTRUMENT MUST STAND CLEAR OF WALL AND (OR) FITTINGS TO PREVENT TRANSMISSION OF BUILDING VIBRATIONS & TO ALLOW CLEARANCE FOR DOOR HANDLES WHEN DOORS ARE FULLY OPEN.
EXTERNAL GND.
TO ROOM LIGHTS
POWER SUPPLY
115V-60~
VOLTAGE STABILIZER
115 V-60~
PUMP ON SHOCK MOUNTED BASE & IN SOUND SUPPRESSION HOUSING (PX-277149)
WASTE WATER DRAIN
COLD WATER INLET
SHUT OFF VALVE
POWER CONSUMPTION DIFFUSION PUMP ONLY 345 WATTS
POWER CONSUMPTION MICROSCOPE & DIFF. PUMP 1055 WATTS
CUSTOMER'S WALL SWITCH
POWER LINE
ROOM LIGHT
CABLE CONNECTION TO CONTROL PANEL.
WGT. 875 LBS.
FLOOR LOADING 220 LBS./FT.²
HOLES FOR HOSE & POWER LINES. TWO GROUPS LOCATED IN REAR & ONE GROUP LOCATED IN BOTTOM, RH SIDE & L.H. SIDE. SELECT MOST CONVENIENT GROUP AT INSTALLATION & INSERT GROMMETS IN HOLES USED. NO CONDUIT OR OTHER SOLID CONNECTION SHOULD BE MADE TO MICROSCOPE CABINET-TO PREVENT TRANSMISSION OF BUILDING VIBRATION. SUITABLE TREADWAY CAN BE CONSTRUCTED TO PROTECT HOSE & POWER CONNECTIONS.
16 CLEARANCE TO RAISE HOOD
73
22½
19
22
DOORS OPEN BOTH SIDES. TOTAL CLEARANCE 5 FT.
INSTRUMENT MOUNTED ON RUBBER PADS SUPPLIED BY RCA.
A
B
C
D
E
F
G

CIRCUIT	DESCRIPTION	REMARKS	SUPPLIED BY
A	3/8 O.D. COPPER TUBING	COLD WATER FEED LINE FOR DIFFUSION PUMP (3CC/SEC)	CUSTOMER
B	3/8 O.D. COPPER TUBING	WASTE WATER LINE	CUSTOMER
C	RUBBER TUBING 5/8 I.D. x 3/8 WALL	FOR JOINING VACUUM LINE UNITS & ABSORBING PUMP VIBRATION	RCA
D	SEAMLESS BRASS OR COPPER TUBING 3/4 O.D. x 1/16 WALL	VACUUM LINE NOTE: ENDS MUST BE HIGHLY POLISHED & TINNED FOR 2" LENGTH TO SUIT INSTALLATION	RCA
E	POWER LINE PUMP	115 VOLT 60 CYCLE STARTING-18 AMP. RUNNING-7 AMP.	CUSTOMER
F	MAIN POWER SUPPLY	STABILIZER RATING (INPUT 90-130V.) (OUTPUT 115 V.) 1KVA 60∿	CUSTOMER
G	ROOM LIGHTS CONTROL	3 WAY SYSTEM (MAX. RAT.-6 AMP.-250V.; 12 AMP.-125V.)	CUSTOMER

Figure 9—Installation Layout (*P*-719100)

The electron microscope is dismantled sectionally at the factory and shipped in a number of individual crates. Because the microscope is to be assembled and installed only by experienced personnel, no detailed instructions are given here. The directions for reassembling after regular maintenance work has been done will be given in the "Maintenance" section of this book. However, a few general directions should be followed. An overall installation layout is given in Figure 9. This should be followed as closely as possible.

UNPACKING—A number of precautions should be observed when the microscope is being unpacked. Such precautions are:

a. Avoid using excessive force with heavy tools such as crowbars, hammers, etc.

b. All parts, after they are unpacked, should be set carefully in a safe place where there will be no danger of tipping or falling.

c. Do not handle the fluorescent screens and bellows.

ASSEMBLY—Locate the base of the electron microscope on a reasonably level floor, conveniently near water and electrical outlets.

Turn the back of the electron microscope toward a window. This arrangement allows a sufficient amount of natural light in the room and, at the same time, the cabinet acts as a light shield during the course of operation. However, it should be possible to darken the room if necessary.

Although the instrument is shock-mounted, as an additional precaution, the site chosen for the microscope should be reasonably free from externally caused vibrations, and not within a strong variable magnetic field. It will be found convenient to have a photographic dark room in the immediate vicinity of the room in which the microscope is installed.

INSTALLATION OF ROTARY PUMPS—The preferred approximate location of the main and auxiliary pumps is shown in the overall installation layout, Figure 9. The care to be given the pumps before placing them in operation, as well as during actual service, is described in detail in the "Maintenance" section of this Instruction Book.

It is recommended that the pumps be installed in a sound-proof housing. The housing detailed in Drawing PX-277149 of Figure 7 consists of a strong box built of ¾-inch, 3-ply for panels, securely nailed together. It is equipped with a forced draft ventilation system to which must be attached a fan blade such as the one detailed in the drawing.

It will be noted that the box is completely lined inside and covered outside with one-inch thick "Ozite" insulating felt, or similar sound absorbing upholstery. For successful operation the box must be completely covered as shown. Most of the noise is absorbed by the inside layer of "Ozite." Very little sound can reach the wood and cause it to resonate. What little sound does get through the wood is almost completely absorbed by the outside covering of "Ozite."

One-inch long shingle nails or staples may be used to hold the "Ozite" in place. For the inside layer, glue is best since it would increase the damping effect of the "Ozite" relative to the woodwork. However, gluing leads to apparent difficulties. Joining of the various pieces of "Ozite" shown in the drawing is arbitrary. Continuous pieces are not necessary as long as the joints are pushed closely together. Certain joints may be improved by basting them together with ordinary string and darning needle.

USE OF THE THREE-WAY STOP-COCKS WITH ROTARY PUMPS

The EMU microscope is equipped with a 3-way glass stop-cock for sealing the lines from the rotary pump. The 3-way stop-cock is of the type which permits a main orifice to be connected to, or completely shut off from, either one of the two pump channels.

EXTERNAL CONNECTIONS—The external connections of the vacuum and water lines and of the electric cables depend on the particular conditions of each individual installation. Reference should be made to the installation layout drawing of Figure 9.

TYPE EMU

ELECTRON MICROSCOPES

WARNING

PLEASE READ THESE INSTRUCTIONS CAREFULLY

1—WHEN EITHER THE RIGHT OR LEFT CABINET DOOR IS OPENED, ALL POWER IS REMOVED FROM THE CHASSIS AND OTHER UNITS, **EXCEPT** THE FOLLOWING:
- A–115 VOLTS A.C. FROM VOLTAGE STABILIZER THROUGH LOWER CHASSIS TO DIFFUSION PUMP—AS INDICATED IN SCHEMATIC.
- B–385 VOLTS, 45 VOLTS AND 22½ VOLTS (D.C. BATTERY SUPPLIES) FROM BATTERY ON LEFT CABINET DOOR TO UPPER CHASSIS, AND
- C–"ROOM LIGHTING" POWER (IF CONVENIENCE SWITCH IS USED) FROM LOCAL ROOM POWER SOURCE TO "ROOM LIGHTS" SWITCH ON CONTROL PANEL.

2—TO REMOVE **ALL** POWER FROM THE CHASSIS OR COMPONENT PARTS OF THE MICROSCOPE, DO THE FOLLOWING IN THE ORDER SHOWN:
- A–SHUT OFF POWER INPUT TO VOLTAGE STABILIZER (VALVING SYSTEM SHOULD BE IN "NEUTRAL" OR "LOADING" POSITION,—SEE INSTRUCTION BOOK).
- B–OPEN LEFT CABINET DOOR AND DISCONNECT BATTERY SUPPLY CABLE FROM BATTERY SUPPLY BOX.
- C–OPEN RIGHT CABINET DOOR AND DISCONNECT "ROOM LIGHTING" CABLE BY SEPARATING MALE AND FEMALE CONNECTORS. (NOTE: IF TEMPORARY CONTINUANCE OF ROOM LIGHTING IS REQUIRED, INSERT "SHORTING" PLUG FIXTURE, SUPPLIED WITH MICROSCOPE ACCESSORIES, INTO FEMALE CONNECTOR OF ROOM LIGHTING POWER FEED CABLE).

3—**BEFORE** HANDLING ANY PART OF THE **HIGH VOLTAGE CHASSIS,** DO THE FOLLOWING:
- A–INSPECT AUTOMATIC GROUNDING MECHANISM. THIS DEVICE CAUSES THREE RODS TO FALL AGAINST VOLTAGE STORING CIRCUITS OF THE HIGH VOLTAGE CHASSIS WHEN EITHER OR BOTH OF THE CABINET DOORS ARE OPENED AND THEREBY NEUTRALIZES THE VOLTAGES.

4—**ALWAYS** CHECK THE CABLE OF THE **GROUNDING ROD** BEFORE USE. THE CABLE SHOULD BE CONTINUOUS AND IT SHOULD BE SECURELY FASTENED TO THE FRAME OF THE MICROSCOPE.

5—**ALWAYS** USE THE CONDUCTING END OF THE **GROUNDING ROD** TO NEUTRALIZE VOLTAGES BEFORE MAKING PHYSICAL CONTACT. IT IS GOOD PRACTICE TO LEAVE THE GROUNDING ROD HOOKED OVER AN ELECTRICALLY CONDUCTING SURFACE OF ANY PART BEING CHECKED OR HANDLED.

6—RAISING THE **TOP HOOD** OF THE MICROSCOPE OPERATES THE FOLLOWING:
- A–AN INTERLOCK WHICH OPENS THE POWER SUPPLY FEED TO THE HIGH VOLTAGE CHASSIS.
- B–AN AUTOMATIC GROUNDING BAR WHICH NEUTRALIZES THE VOLTAGE WHICH MAY BE STORED IN THE CIRCUIT TO THE ELECTRON GUN.

7—**BEFORE** TOUCHING ANY OF THE **ELECTRON GUN** COMPONENTS WHICH ARE EXPOSED WHEN THE TOP HOOD IS RAISED, **ALWAYS** HOOK THE GROUNDING ROD ON SOME CONVENIENT METAL PORTION OF THE ELECTRON GUN HIGH VOLTAGE CIRCUIT, I.E., ANY POINT BETWEEN THE END OF GUN TRANSFORMER UP TO AND INCLUDING THE CORONA RING AT THE TOP OF THE GUN.

8—**BEFORE** REMOVING THE **CONSOLE SHELF** TO EXAMINE THE **CONTROL PANEL,** PERFORM AND EXERCISE THE SAFETY PRECAUTIONS OUTLINED IN PARAGRAPH NO. 2 ABOVE. REMOVAL OF THE CONSOLE SHELF **DOES NOT** ACTUATE ANY PROTECTIVE INTERLOCKS.

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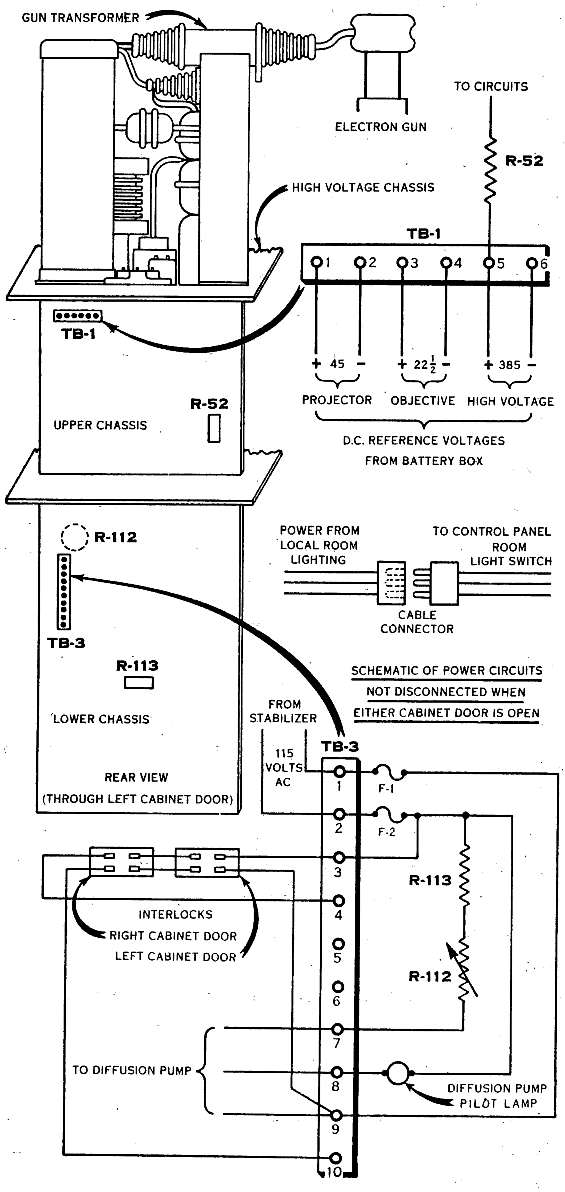
CAMDEN, N. J. MADE IN U. S. A.



The operation of the electron microscope is simple after the fundamental concepts of design have become familiar. It is suggested for this reason that the operator should read the foregoing sections before attempting to operate the instrument. In the remainder of this section, the subject matter will be divided with respect to the three forms of technique involved in operation. These techniques pertain to the excitation of the instrument, the handling of specimens and the procurement of electron micrographs.

WARNING—Operation of the electron microscope involves the use of voltages which are dangerous to life. Do not change tubes or make adjustments inside the equipment with the high voltages "ON."

EXCITATION TECHNIQUE

In energizing the electron microscope, there are three major factors to be considered and properly coordinated before electron images can be viewed or photographed. First, a vacuum of the order of 0.1 micron (10^{-4} mm of mercury) or better must be obtained in the large column of the microscope; second, the excitation voltages must be applied to the electron gun and field lens coils of the magnification system; and third, the electron beam must be correctly aligned with the microscope axis and focused to obtain the desired type of illumination.

OBTAINING BEAM AND IMAGE—The following procedure should be observed in evacuating the microscope column:

1. Throw the "MAIN POWER" and "HIGH VOLTAGE" toggle switches to the "OFF" (left) position. Make certain that both cabinet doors are closed and the top hood is down.

2. Throw the "PANEL LIGHTS" toggle switch "ON" (right). The position of the "ROOM LIGHTS" switch is optional.

3. Turn the crank handle on the side of the microscope till the dial reads "LOADING."

4. Turn on the power to the line voltage stabilizer and fore pump. Then turn stop-cock so the fore pump is pumping the diffusion pump.

5. The diffusion pump will take ten to twenty minutes to "warm up." During this time the "FORE PRESSURE" meter reading will rise. As the diffusion pump warms up, the "FORE PRESSURE" meter reading may decrease slightly.

6. After about 5 minutes, turn the valve control (the crank handle on the side of the microscope) to "PRE-PUMP" position. The "FORE PRESSURE" meter reading will drop near zero and then rise again.

NOTE—The meters are calibrated at the factory; no further adjustment is necessary.

7. When the "FORE PRESSURE" meter reads "50" and the "COLUMN PRESSURE" meter reading, rising, reaches "5," advance the valve control to "OPERATE" position. The "COLUMN PRESSURE" meter reading will continue to rise as the diffusion pump warms up until maximum reading approaches full scale. When the diffusion pump is heated and begins to operate, the "COLUMN PRESSURE" meter reading will decrease.

8. When the "COLUMN PRESSURE" reading decreases to "3" a satisfactory pressure in the column has been reached.

9. Turn on the "MAIN POWER" switch on the control panel.

10. When the "TEST" meter reading settles at 60 with the meter switch in "PROJ" position, turn on the "HIGH VOLTAGE." The "BEAM" meter current reading should be about .05 in a few seconds' time.

11. If the "OVERLOAD" lamp lights, throw the "HIGH VOLTAGE" switch to "OFF" (left) position, wait a few seconds and turn "HIGH VOLTAGE" on again.

12. Advance "GUN FILAMENT" control until the "BEAM" current meter reads between .2 and .5.

13. Adjust the specimen, electron gun and "INTENSITY" controls until the image appears on the intermediate and final viewing screens.

14. Check position of lens switches for the type of operation desired.

ALIGNMENT OF THE ELECTRON BEAM—The following description applies to a step-by-step procedure for aligning the microscope column to obtain proper performance of the instrument. It is presumed, of course, that all parts of the instrument have been thoroughly cleaned and adjusted as described earlier.

1. **FILAMENT FOCUSING (COARSE)**—The action is observed at the primary viewing screen. The condenser, objective and projector lens settings are arbitrary. The specimen holder and objective aperture are not used.

Lower the electron gun filament by means of the adjusting tool provided with the instrument. Rotate the tool clockwise to lower the filament. At some low position of the filament an astroid will appear as shown in Figure 10(1). The rotational position of the astroid is arbitrary.

Raise the filament by counterclockwise rotation of the adjusting tool. The filament image will go through the sequences 2, 3 and 4 as shown in Figure 10. At the required height, the astroid form disappears and the image is blurred. The tilt screws of the electron gun are now adjusted to permit the filament image to disappear into the hole in the primary viewing screen.

2. **OBTAINING THE BEAM**—The action is observed at the intermediate screen. The condenser lens current is set to approximately 23

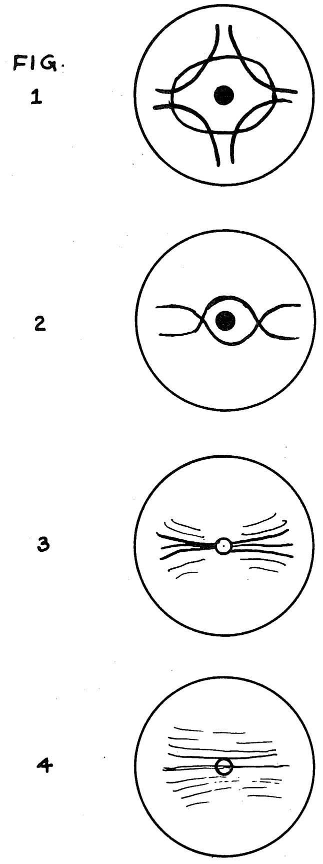


Figure 10—*Electron Gun Filament Images* (*KX*-387581)

ma. The objective lens current is set to approximately 30 ma. The projector setting is arbitrary. The specimen holder and objective aperture are not used.

The condenser lens is approximately centered by eye. The electron gun is moved laterally until illumination is obtained on the intermediate screen.

3. **FILAMENT FOCUSING (FINE)** — The action is observed on the intermediate screen. The condenser, objective and projector lenses currents are set as in the preceding step (2). The specimen holder and objective aperture are not used.

The condenser current is reduced slowly from a high value until the illumination is seen to move off the intermediate screen. Illumination is brought back by lateral adjustment of the electron gun. Continue reducing the condenser current and readjusting the lateral screws if necessary until maximum intensity and minimum spot size are obtained. This condition of the condenser is known as condenser focus or "crossover."

Caution—Shut off the high voltage before changing height of the electron gun, and discharge the gun by means of a grounding rod.

The height of the electron gun is now varied with the filament height adjusting tool until the central bright spot is about ¼″ long as seen on the intermediate screen. Any bright areas or reflections surrounding the central bright spot may be observed by lowering the objective current slightly. If the bright filament image is not in the center of the pattern, tilting of the electron gun followed by a compensating lateral adjustment should accomplish the desired result.

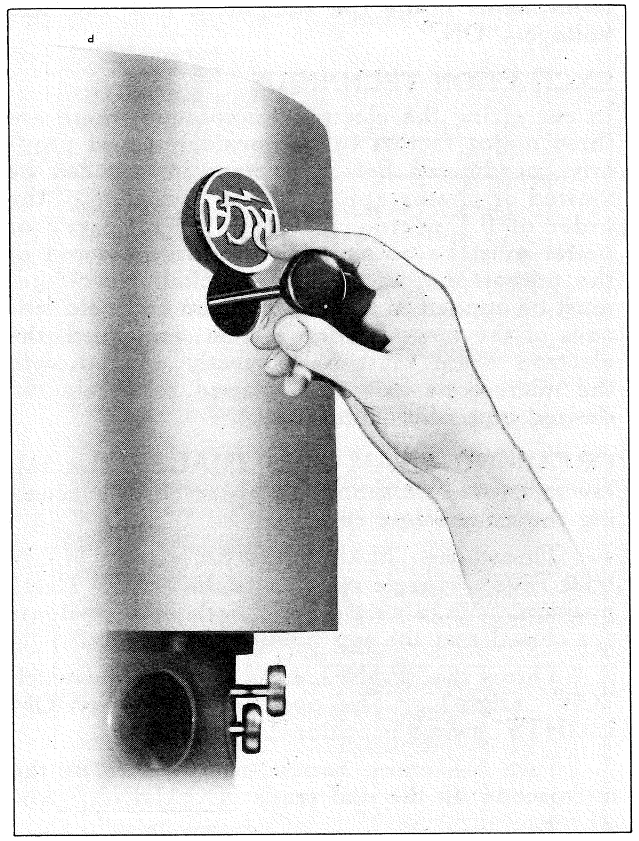


Figure 11—*Adjustment of Electron Gun Height*

4. **OBJECTIVE-PROJECTOR LENS ALIGNMENT (COARSE)**—The action is observed on the final screen. The condenser is focused for maximum illumination. The objective current is set to its focal value with a specimen in position. The magnification control is set to Step 1 with the short projector pole piece spacer. The specimen holder with a suitable specimen is used. The objective aperture is omitted.

A focused image of the specimen is obtained. The objective current is varied by means of the "Focus 2" Control, and the apparent center of rotation of the final image is located. The center of image rotation is moved to the center of the screen by transverse adjustment of the objective lens. The center of rotation of the image may be off the screen by several inches and as a result may not be illuminated. Transverse motion of the electron gun is used to keep the illumination on the screen.

If the center of rotation of the image does not remain at a fixed point in the image as the objective current is changed from the focal value, the center of rotation near focus is used as the criterion for adjustment.

Under some circumstances, it may be found that the objective lens has been moved laterally in a given direction as far as possible without allowing the apparent center of rotation of the image to be brought on the final viewing screen. In this case, rotation of the objective pole piece through an angle of 180° about its axis in the objective coil will allow the mechanical and electrical axes to more nearly coincide, and thereby permit proper alignment.

5. **CONDENSER-OBJECTIVE ALIGNMENT**—The action is observed on the final screen. The condenser current is set to some high value. The magnification control is set at Step 1 with the short projector pole piece spacer. The specimen holder is used with a suitable specimen in position. The objective aperture is omitted.

Observe the image on the final screen as the objective current is reduced from its focal value. That portion of the image which moves off the final screen is returned by lateral adjustment of the condenser lens. This adjustment is continued until the lowest objective current is reached. Repeat adjustments (4) and (5) until the part of the image near the center of rotation at focus appears at the center of the screen for the lowest and focal values of objective current, and wanders a minimum amount for intermediate values. Compensating lateral adjustment of the electron gun may be necessary during the above procedures. On final adjustment, the center of rotation of the image should not wander more than a centimeter from the center of the screen as the Focus 2 knob is given a complete rotation.

6. **GUN ALIGNMENT**—The final check on gun alignment is obtained by observing the image of a suitable specimen on the final screen with the condenser focused for maximum intensity, and the magnification control set to Step 1 with the short spacer in the projector pole piece. As the objective current is decreased from focus, the image on the final screen should blur out equally in all directions. Two distinct images which appear as the objective current is decreased from focus, and which merge when the objective is refocused, indicate the need for slight further gun tilt, lateral or filament height adjustment, or a combination of all three.

SPECIMEN TECHNIQUE—The following paragraphs are a discussion on the technique in three stages, namely, insertion, examination, and removal of the specimen.

Insertion of the Specimen—Before a specimen can be examined in the electron microscope it must be properly prepared and placed in one of the specimen holders supplied with the equipment. The preparation of specimens is outlined in a later section. The standard and stereoscopic holders are described in the section on viewing and photographic facilities.

The standard holder is adjustable over a range of about 22,000 diameters. The method for obtaining these various adjustments is discussed under the paragraph on "Pole Pieces."

Because the stereo-holder needs room to be tilted, the holder must be set higher than the standard holder. This arrangement causes a slight loss in magnification.

As described later, the specimen is prepared on a supporting screen, about ⅛ inch diameter, made of fine metal mesh. To place this screen into the specimen holder (standard or stereoscopic type) proceed as follows:

(1) Remove the cap from the small tubular (lower) end of the specimen holder body.

(2) Place the specimen screen into the cap.

(3) Insert the lower tubular end of the holder body into the cap.

Figure 12—*Removal or Installation of Stereo Door*

The holder is now ready to be placed into the specimen chamber of the microscope. This is done as follows:

(1) Allow air to fill the microscope column, by turning the handcrank on the right-hand side of the microscope into the "loading" position, as shown on the dial on the right.

(2) Filling of the microscope with air to outside pressure will require approximately one minute.

(3) The door of the specimen chamber, located on the front of the microscope column can now be opened by simply lifting it off the specimen chamber opening.

(4) Place the specimen holder into the special scissors tongs provided for the purpose. These tongs have two small stud grips which fit into corresponding holes in the body of the specimen holder. The holder should be held so that the cap is at the bottom, and the keyway in the holder body oriented toward the rear of the microscope, away from the operator.

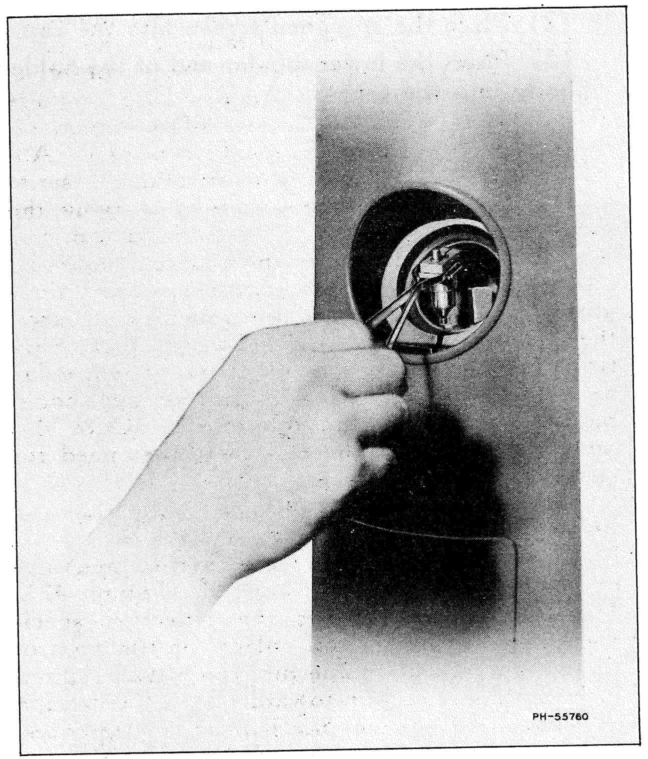


Figure 13—Insertion of Specimen Holder

(5) Through the specimen chamber door opening, insert the holder into the pole piece orifice, rocking it gently so that the keyway in the holder will engage with a corresponding key in the pole piece orifice. The holder will then fall into place, and the tongs can be released. Do not use force during this operation.

(6) In case of the stereo-holder, place this into the neutral (center) position, and place the stereo-door knob also in neutral position (this is indicated by a small mark on the door knob, which must point upward).

(7) Close the specimen chamber by placing the door over the door opening. When the stereo-door is used, its keyway (notch) must be oriented toward the bottom, to match a corresponding key at the bottom of the specimen chamber door opening. The door will be held firmly in place over the door opening as soon as vacuum has again been obtained within the microscope column.

Viewing and Examination of the Specimen— When the specimen holder is inserted it is directly in the path of the electron beam. Because of the relatively low degree of magnification at this point, a large portion of the specimen is within the field of observation, and this entire field may be explored for interest value.

Two remote crank knobs on the panel of the instrument control the alignment of that portion of the specimen which is to be used in final magnification and as a subject for photography.

To remove the specimen, turn the crank handle on the side of the instrument till the dial reads "loading" to admit air into the column. After about one minute has elapsed the door can be easily removed. The holder is withdrawn with the forceps, carefully, as it was inserted. Do not use force.

ELECTRON DIFFRACTION WORK

In diffraction work, column alignment is of prime importance, particularly electron gun focusing. Incorrect gun focusing is apt to produce multiple images in the diffraction pattern. Proper alignment insures optimum patterns and aids in securing maximum intensity, a condition which diffraction technique requires.

The condenser and its control are employed as in regular micrograph work for the control of beam intensity. The objective lens and its controls are used to produce a properly located image of the source of the electrons with respect to the specimen. To set the electrical circuits for typical diffraction work, the procedure is as follows:

1. Turn on main power.
2. Turn on high voltage—50 kv.
3. Regulate beam current to about 400 microamps.
4. Set switch S-7 in "DIFF." position.

The above described routine covers the normal electrical circuit set-up, with the exception of the objective lens and the settings of its controls.

Transmission Diffraction

To produce a transmission diffraction, the following steps should be followed:

1. Prepare specimen, using standard specimen screen as supporting means. Good test patterns may be obtained from the smoke of zinc burned in an oxygen flame, or magnesium burned in air. The proper amount of smoke to be collected on the screen is a compromise between the quantity generally acceptable for micrograph work and a quantity almost sufficient to make the screen appear opaque to light. This note on quantity of specimen applies equally well to all transmission studies. Test specimens may also be prepared from suitable, preferably highly crystalline substances, using any of the regular screen and film methods of specimen preparation. In addition to the oxide smokes mentioned above, two materials which produce excellent sharp rings for focusing control adjustment are Attapulgus Clay and Montmorillonite.

2. The prepared screen and specimen are mounted in the removable cap of the transmission holder Figure 44. The removable cap is mechanically the same as the cap of the regular micrograph specimen holder and may be used interchangeably with it. The aperture of the transmission holder requires the strict cleanliness demanded by any other units in the electron beam axis system. In diffraction work no objective aperture is required.

3. The loaded holder is placed in the holder seat of the universal stage so that the aperture faces the electron source. It is convenient to have the control bridge of the reflection holder mechanism in a vertical position so that it is out of the way. The "ANG" adjustment wheel will provide this condition. Likewise, the reflection holder should be removed, and its control shaft drawn out of the way by means of the "TR" adjusting wheel.

4. The electrical circuits are set up as described previously and the objective lens current is adjusted to a value of approximately 5 ma. (coarse control 2). The electron gun and condenser lens are adjusted to give maximum intensity of the source image through the aperture of the intermediate viewing screen. While the condenser lens is being adjusted for maximum intensity, a series of concentric rings forming the diffraction pattern should appear on the final viewing screen. The procedure of this paragraph is intended for test and alignment purposes only, and, of course, may be employed at any time for visual check of column or specimen conditions. Patterns may not always be evident, however, due to insufficient image intensity. Image intensity is a function of the density of the specimen and its crystalline characteristics. Diffraction patterns are photographed at a different value of objective current as described in the following paragraph.

5. Diffraction patterns are photographed at an objective lens current of about 30 ma. With this higher value of objective current, the intensity of the pattern is greatly reduced as compared to that obtained at lower objective current. In most cases, the pattern rings will not be evident. However, a small spot image of the undiffracted beam will be clearly visible. The brightness of this spot can be varied by changing the condenser lens current. In photographing a diffraction pattern, it is generally best to obtain all the illumination possible, without, however, using the condenser control at the point where maximum illumination is obtained. The optimum setting of the condenser control, taking into account the intensity of the diffraction pattern, is at a point slightly off maximum intensity.

Photographic exposures may require from 15 to 45 seconds depending on the intensity of the pattern. A small amount of experience with the beam spot brightness will readily disclose proper time exposure values. Standard 2 x 10 medium lantern slide plates are regularly used for diffraction pattern photography although special conditions may warrant experiment with emulsions of greater contrast characteristics. Since diffraction patterns possess a very wide range of contrast values, contact printing or enlarging requires special attention for optimum results.

Adjustment of the "DIFF. FOCUS" control is obtained by the following procedures: the diffraction focus control is varied through its entire range while observing the electron beam spot. It will be noted that the spot reaches a minimum size somewhere in the mid-range of the focus control. Moving the diffraction focus control in either direction will then tend to enlarge the size of the beam spot. The point of minimum dimension is close to correct focal adjustment. Absolute adjustment is obtained by taking a series of exposures of a given specimen, varying the focus setting a few steps (one graduation or less per step) on either side of the experimental focal setting. By studying the sharpness of the rings given by the negatives of the several exposures, the correct setting for the diffraction focus control will be found. (The objective current value as well as the diffraction control setting should be recorded for future reference.) Once this point is determined there is no further need for adjustment.

Reflection Diffraction

For reflection diffraction work, a specimen support and aperture are provided (Figure 42). The bottom view shows the reflection specimen holder slipped into place on its control shaft. The reflection aperture is always mounted with its sloping section toward the control bridge mechanism to prevent mechanical interferences. There are numerous methods by which specimens may be fastened to the holder such as cementing, soldering, etc. A soft copper foil may be soldered to the holder and the loose ends wrapped around the edges of the specimen to hold it in place. Other designs of support may be required for special applications. These can be easily turned from brass, the dimensions of interest being the hold for the control shaft which should be 0.045″ journal finish and the spring type saw slot which should be 0.015″ wide. In other cases, specimens may be mounted directly on the control shaft and the holder omitted. In these instances, the specimen is drilled about half way through with an 0.052″ drill and the specimen slipped on the shaft, using thin copper foil as a binding wedge. The smokes of metallic oxides can be collected on the reflection holder front surface and patterns obtained. This is simply to show that certain materials may be readily examined by either transmission or reflection techniques and may suggest alternate methods of obtaining patterns under special conditions for problem materials.

The electrical circuit routine is identical for transmission and reflection studies.

Figure 42 shows the universal stage and its three hand-wheels which are used to control specimen positioning for reflection studies. The control "TR" moves the specimen in a direction normal to the electron beam axis or into and out of the beam in a lateral direction. The control "ROT" permits the specimen to be rotated continuously about the axis of its control shaft. The control "ANG" permits rotation of the specimen about an axis which is normal to the control shaft axis. All three controls are capable of independent or simultaneous manipulation, and the three freedoms of movement provided thereby, permit the electron beam to strike the crystal lamellae at any desired angle. The following data relate to the mechanical specification of the reflection specimen controls.

1. TR—Transverse—

total movement	0.125″
total turns	4
thread pitch	40
dial index	25 divisions
each division	0.001

2. ROT—Rotary—

total movement	360°
total turns	continuous
dial index	72 divisions
each division	5°

3. ANG—Angular—

total movement	±8°
total turns	4
thread pitch	32
dial index	40 divisions
each division	0.1°

Assuming that the reflection specimen holder and specimen are in a plane parallel to the beam (angular control adjusted so that control bridge is at right angles to universal holder axis) the specimen is advanced into the electron beam until it appears to be about half-way through it, as judged by the beam spot or the half diffraction rings, if visible. The rotary and angular controls are now adjusted until maximum brightness of the half-ring pattern is obtained. The above-described adjustments are made at the prescribed low value of objective current to simplify pattern location and to obtain proper crystal orientation. Once the brightest half-ring pattern is found, the objective lens may be restored to its higher or operating value of objective lens current. While making changes in the specimen position by means of the angular and rotary controls, it may be necessary to make slight changes in the transverse adjustment so that the electron beam is continually producing full-dimensioned, semicircular patterns. When the dimensions indices of the control wheels for crystal plane studies are used, proper allowance must be made for the small amount of mechanical play existing at the control wheel bearings.

During either transmission or reflection work the "DIFF-PROJ" switch may be thrown to the "PROJ" position. In the case of transmission patterns, a small shadowgraph will appear on the viewing screen, showing the portion of the specimen screen and its contents employed in the diffraction study. The shadowgraph will tend to disclose whether or not the specimen distribution and density are suitable for the desired results. The shadowgraph of the reflection specimen on the viewing screen will disclose the location of the specimen with respect to the electron beam axis and will sometimes aid in positioning a particular portion of the specimen to the exclusion of others.

General Notes on Diffraction Work

The dummy stage Figure 41 has been designed for two purposes, namely, (1) to provide a seal for the microscope column when the universal stage is not in use and (2) to provide a fixture for special studies. Through the combination of the dummy plug and other fittings which may be substituted for the front viewing port, it is possible to provide means for spraying a specimen undergoing diffraction observation with low velocity electrons and thereby reduce the electrostatic charge assumed by certain materials; means for mechanically agitating the surfaces of various materials thereby preventing surface contamination, oxides, etc., from contributing to the diffraction pattern; means for evaporating materials so that their patterns may be obtained after evaporation, etc.

Concerning the preparation of metal surfaces for diffraction studies, reference should be made to the contents of the bibliography listed below as well as other publications relating to the same subject.

1. Thompson and Cochrane
Theory and Practice of Electron Diffraction
Macmillan and Co.
New York
1939

2. Clark
Applied X-rays
McGraw-Hill Book Co.
New York
1940

3. Reviews of Modern Physics
Volume 8, No. 3
July, 1936

4. Journal of the Optical Society of America
Volume 30, No. 9
September, 1940

5. Hillier, Baker and Zworykin
A Diffraction Adaptor for the Electron Microscope
Journal of Applied Physics
Volume 13, No. 9—571-577
September, 1942

6. Hanawalt, Rinn and Frewel
Chemical Analysis by X-ray Diffraction
Industrial and Engineering Chemistry
Pub. 11A—538—Volume 10—No. 9
September, 1938

7. Transactions of the Faraday Society
Volume 31—Part 9a, pp. 1043-1136
September, 1935

8. Picard
Studies with the Electron Microscope Diffraction Adaptor
Journal of Applied Physics
Volume 15, No. 9—678-684
September, 1944

The American Society of Testing Materials can supply an excellent card file—"X-ray Diffraction Data" which reveals lattice spacings and relative intensity data of several hundreds of chemical substances and compounds. This index is practically an indispensable reference for diffraction studies and analyses.

Calibration of the diffraction unit can be made by photographing a pattern of a material for which the lattice spacings are accurately known. Measurements are then made by means of a microdensitometer and the diameter of the brightest ring obtained. The brightest ring diameter is converted to Angstrom units and substituted for D in the following equation:

$$D \times d_{hkl} = K_1$$

where d_{hkl} is the known lattice spacing for the brightest ring of the chosen standard material. K_1 then becomes an instrumental constant corresponding to the fixed electrical and mechanical conditions under which the pattern data were obtained. Thus, the lattice spacings for an unknown substance may be computed, using the measured ring diameters in the decreasing order of their relative intensity from

$$d_{hkl} = \frac{K_1}{D}$$

The above formulae are a direct consequence of the Bragg law: $n \lambda = 2 d_{hkl} \sin \theta$ and hold for small angles only, such as are encountered in the Diffraction Unit. The constant K_1 is determined by the dimensions of the diffraction camera and the wavelength associated with the electrons. K_1 will remain a suitable calibration constant for the fixed values of accelerating voltage and objective and diffraction lens currents under which the calibration data were obtained. However, since these voltages and currents are dependent on dry cell batteries for their constancy, it is advisable to re-check the calibration constant (K_1) at least once a month.

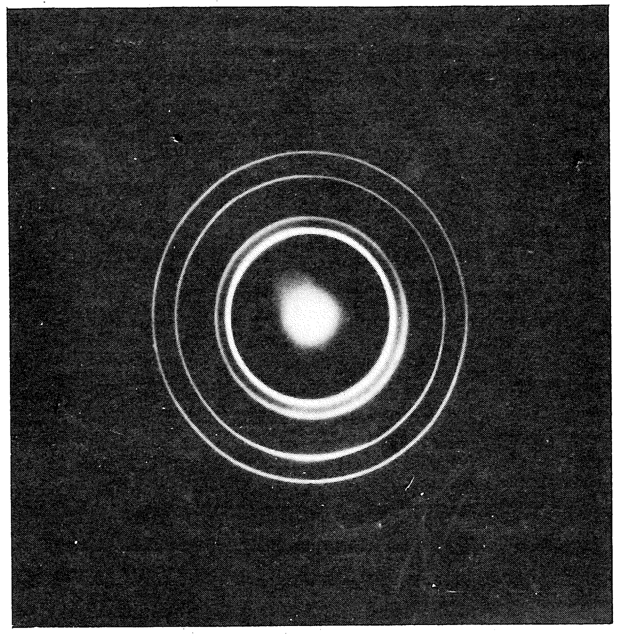


Figure 14—*Standard Diffraction Pattern of Gold*

Figure 14 is an enlargement of a typical diffraction pattern (gold evaporated on supporting film).

Two spurious effects may be encountered in diffraction studies. The first is caused by the diffraction pattern given by the supporting medium used in transmission techniques. This effect is described in detail on page 1057 of reference No. 7 given above. The second effect is produced by the light given off by the gun filament. Under proper conditions of high beam current and long exposure the photographic film will be sensitized and a central spot will be produced, which should not be confused with the patterns produced by the beam itself.

The reflection specimen adjustment control shafts are sealed against atmospheric pressure by means of a rubber grommet type of seal. The two rubber seals are prelubricated before shipment and will, from time to time, require additional lubrication. The lubrication point is identified as "Lubrication" on Figure 42. Ample space has been provided to set up a proper head of lubricant. The recommended lubricant is a mixture of octoil and graphite—about ten to twenty parts of octoil to one of graphite, thoroughly emulsified.

Distance transmission specimen to photographic plate—10.265 in. = 261 mm.

Distance center of reflection specimen to photographic plate—10.140 in. = 258 mm.

ELECTRON MICROGRAPH TECHNIQUE—

Electron micrograph technique deals exclusively with procedures involved in photographing a specimen. The methods to be employed are discussed in the following paragraphs:

Insertion of Plate

The photographic plate is enclosed in a cassette which is light tight to enable the instrument loading to be accomplished in a lighted laboratory. The door to the photographic chamber is located on the right-hand side of the instrument directly below the table top. The cassette snaps into a carriage which runs in grooves in the walls of the photographic chamber. The door can be closed and locked by rotating the handle on the door clockwise into place. The instrument can then be pumped down for operation.

Motion of Plate

Motion is imparted to the plate by a shaft passing through a rubber gasket into the photographic chamber. The cassette control knob, which is located on the vertical part of the control panel, is calibrated to indicate the position of the plate. The control knob should be in the "load" position when the cassette is inserted into the photographic chamber. To place the plate for the first exposure, the control should be turned four and a half turns counterclockwise to the "A" position. Releasing the shutter will then expose the end of the plate nearest the door to the photographic chamber. To make the other exposures the control is turned clockwise nearly one turn until it snaps into place at the desired position. It should be returned to "load" before removing the cassette. The control should be lubricated frequently by filling the oil well in the upper rear part of the knob with the prescribed mixture of octoil and graphite.

Exposure of Plate

To make the exposure the viewing screen is lifted by means of the camera cable release on the control panel. The flexible cable makes it possible for the operator to expose the plate without actually coming in contact with the instrument, and thereby vibrating the microscope column. For a micrograph, an exposure of from one to fifteen seconds is usually used, depending on the intensity of illumination. For making these exposures turn the circular piece on the side of the cable release so that it slides under the small button. This arrangement simulates "snap-shot" action. Diffraction patterns are usually photographed with an exposure of from 30 to 60 seconds. The circular piece on the cable release should be turned so that the notch on the edge is directly under the button. This arrangement provides "timed" exposure conditions and relieves the operator from holding the cable release for long periods of time. The sliding doors on either side of the viewing chamber are closed during exposures to keep the light in the room from fogging the plate.

Removal of Plate

Before removing the plate, the high voltage and gun filament are turned off and air let into the column. The lock on the door to the photographic chamber is lifted and the door opened. The carriage which holds the cassette is permanently mounted in the photographic chamber. The cassette release should be lifted and pulled toward the operator. The cassette can be withdrawn and taken to a dark room to be unloaded and developed.

STEREO-MICROGRAPHS

Stereo-micrographs may be obtained through use of a special specimen holder (Stock #48404). When employed as described below, this holder will produce micrographs having a magnification nearly as great as that obtained with specimen holder (Stock #48390).

In optical light microscopy, information regarding the three-dimensional structure of materials may be obtained by one of at least three methods, namely: series sections, optical sectioning, and stereo-photomicrography. The nature of the electron microscope specimens and the enormous depth of focus obtained in electron microscope images prevent the electron microscopist from using the first two of these methods. By employing the third method the electron microscope can be readily adapted to produce stereo pictures and give accurate information concerning the third dimensions of specimens. The actual experimental procedure, which is essentially the same as that used in obtaining stereo-pictures with the light microscope, produces micrographs of the same field from slightly different angles. To obtain stereo-micrographs in the electron microscope, a specially constructed specimen holder, provided with a mechanism for adjusting the angle between the axis of the microscope and the normal to the plane of the specimen, is used. Two micrographs of the desired field are made for which the above mentioned angle has equal but opposite values.

When shifting the stereo-holder it is advisable to turn the knob slowly, at the same time watching the image on the intermediate viewing screen. When the specimen holder snaps into position, the image jumps slightly. In this way the operator can identify the exact positions. Remember that the image will also jump in passing the central position. In order to stop the specimen holder at the central position it is necessary to turn the handle slightly past it and then back up. Watch the image closely and move the stage to compensate for any movement of the image on the screen. It is also advisable to adjust the first image on the final viewing screen so that some easily identified point is on the intersection at the center of the screen and be careful that it is on the same point when the second picture is taken.

In order to allow room for tilting the stereo-specimen holder, the specimen screen must be placed somewhat higher above the objective pole piece than with the standard holder. Then adjust the

first image on the final viewing screen so that some easily identified point is on the intersection at the center of the screen and remains at that point when the second picture is taken. Where the actual depth of the material is relatively large, better visual concepts are obtained by reducing the angle of tilt. Obtain a stereo pair made from one tilted view and one with the holder in the mid-position, a total angle of 4°. The only differences in the two micrographs are the slight difference in magnification caused by the slight change in the distance between the specimen point and the objective, and those differences due to the fact that the plane has been tilted through an angle. The former effect is practically negligible. It can be kept to a minimum by restricting the stereo images to areas near the center of the specimen screen. The latter effect, differences in aspect due to tilting, accounts for the stereoscopic or three-dimensional appearance of the specimen when the finished prints are properly viewed.

In order to obtain the proper results, it is essential that the prints used for stereoscopic viewing be suitably prepared and oriented. Proper orientation of the prints is **particularly** important due to the fact that magnetic lenses cause an arbitrary amount of rotation of the image. It is therefore necessary to rotate the prints about corresponding points until all the displacements in the image that are due to the tilting of the specimen are parallel to the line joining the eyes of the observer. A simple way to accomplish this result is to take the stereoscopic pair of prints and superimpose them in front of a bright light so that both images can be seen. Some point in the field is selected as the point that should appear nearest the observer, and the two images of that point are made to coincide. It will then be seen that the images of other corresponding points of the field of view do not exactly coincide, but are displaced slightly relative to one another in arbitrary directions. If the proper foreground point has been selected and the displacements are due to the stereoscopic effect only, the other parts can be made all parallel by rotating one picture over the other until the required condition obtains. The angular position of each print should then be accurately noted and maintained when the prints are permanently mounted for stereoscopic viewing.

A few remarks should be made in regard to the obtaining of successful stereo-micrographs. Specimens which show sign of moving or changing of their own accord while in the electron beam or otherwise, do not in general give true or even good stereo-micrographs. By shortening the time of observation of the specimen between exposures, changes in dimension of parts of the specimen, caused by metal sputtered from the wire screen support, will be reduced to a minimum. This is particularly true of specimens mounted without supporting membrane.

The rules for ordinary stereoscopic photography should be followed in making up prints, attention being paid to those details which can produce confusing effects, such as the position and shape of the borders.

It should also be pointed out that stereo-micrographs obtained in this way produce a dissociation of perspective and three-dimensional parallax phenomena. This is due to the fact that the perspective in the images corresponds to that which would be seen in an object situated in the neighborhood of 100 meters from the eye while the three-dimensional parallax effect corresponds (for an angle of 8°) to that which would be seen in an object at a distance of about 50 centimeters.

CALIBRATION OF THE MAGNIFICATION

(a) First Calibration Method

Generally speaking, calibration of the magnification is measured by comparison of photo-micrographs of a test specimen taken with the Electron Microscope and with a high-powered calibrated light microscope. For this procedure, the specimen is mounted in a standard specimen holder such as described before. A fairly large specimen is chosen; i. e., one which appears in about 3 or 4 openings of the specimen screen (about 150 microns x 150 microns), and which shows a number of readily distinguishable irregularities on its boundaries. The burrs formed by puncturing a specimen screen will make a convenient and rugged calibration specimen. A portion of this specimen is photographed at various settings of the projector control and with the different projector pole piece arrangements. A micrograph is now taken of the whole specimen in a calibrated light microscope and the magnification is computed for the several magnification ranges of the instrument. The light micrograph is used to calibrate the intermediate or low magnification series and the intermediate series is used to calibrate the high magnification steps. Obviously, the use of a larger specimen for the calibrated light micrographs should reduce the error of observed measurements by a large percentage.

(b) Alternate Calibration Method

An alternate method of calibration of the magnification involves the same photographic procedure as described above, but instead of measuring the specimen with a light microscope, a collodion replica is made of a diffraction grating having about 30,000 lines/inch. This replica of known line spacing can be photographed with the electron microscope at a projector setting which permits about a dozen lines to be included in the field and serves as a direct calibration of this projector setting. The replica may be saved and used to recalibrate the microscope at any time.

One precaution must be observed in using this method. The grating replica undergoes some distortion in stripping, and the line spacing should be determined by measuring the replica with a light microscope using a high-power dry objective. Since magnification depends on the current in the objective and projector coils as well as on the electron accelerating voltage, meter readings and control knob settings must be recorded with care for all calibration points. In addition, these readings must be watched for repetitive constancy, once calibration has been made. Presuming that the microscope has been calibrated at fixed values of objective current and accelerating voltage; in a given specimen plane; at various values of projector current control steps, there are certain factors which will affect repetitive accuracy. These are listed below:

1. Line voltage changes—(corrected by line regulating transformer).

2. Inconstancy of specimen plane, caused by variations of specimen height in supporting media; variations in supporting media; mechanical inaccuracies of exact replacement of specimen in calibrated plane.

3. Aberrations—dimensional changes as a result of distortion. These can be reduced to a minimum order, if measurements are confined to the central area of the electron cone.

4. Lens current or accelerating voltage changes (overcome by correcting electronic circuits—tubes, dry battery standards, or component parts).

5. Foreign particles in lens pole pieces (corrected by keeping inner configurations of pole pieces, surfaces of apertures and all points near to the electron beam free of dirt or particles subject to electrostatic charge).

6. Lens hysteresis effects.
These effects are compensated for as follows: The projector and objective current controls should be operated in one direction only (preferably clockwise) when calibrating or making succeeding measurements. Otherwise, hysteresis effects in the iron cores of the deflecting coils will affect the calibration accuracy. If a large change in current direction is required, it is best practice to reduce the affected circuit current to a minimum and advance slowly to the desired value.

It is safe to assume that, if necessary precautions are taken and careful measurements made, the error of magnification computations will not exceed 5 per cent.

NORMAL METER READINGS

Normal meter readings are as follows:

Meter	Actual I or E
Condenser	10-25
Objective	3-80
Projector	150
Filament	0-60
Osc. I	130-150
Osc. E	600-900
Regulator	370

MAINTENANCE

Familiarity with the methods employed in routine care and servicing is essential in maintaining the proper functioning of the microscope. Therefore, the following discussion on "MAINTENANCE" should be carefully read and consulted as an adjunct in the periodic check-ups of the instrument. To obtain the ultimate in micrograph results, it is essential that every electrical and mechanical component of the Electron Microscope—from electron gun to photographic plate—be in good condition and in proper alignment.

WARNING: Voltages used in many of the circuits of the electron microscope are dangerous to life. Circuit checking and trouble shooting should be accomplished by no less than two operators. Even though power has been turned off, certain capacitors in the circuits are capable of storing electrical energy for considerable periods of time at voltages which are dangerous to life. Before touching any of these circuits, they should be grounded and discharged with a "grounding rod." The grounding rod must have a well-insulated handle. It must be grounded through a circuit which must be continuous and of low resistance. The grounding connector must be flexible to withstand usage. It should be exposed so that its continuity may be checked readily. In addition to grounding, it is accepted and good practice to test every circuit requiring examination with a voltmeter, before physical contact is made.

NOTE—As a general rule do not remove tubes from circuits which are in operation.
The following items should be checked regularly as a preventive measure:

a. The oil in the mechanical pump should be drained, the pump flushed with oil, and refilled every three months.

b. The diffusion pump should be drained, cleaned, and refilled every six months.
The vacuum system should be tested for leaks before inserting the oil in the diffusion pump. About 200 grams of Octoil will be required. The fluid may be inserted from the top of the casing, or if the pump is already secured to the rest of the system, the oil may be sucked in through the drain tube at the bottom of the casing by applying the fore pump for a short interval and then screwing the metal cap in place while the inrushing air keeps the oil from flowing out again. When the pressure of the cap gradually causes the lead seat in the cap to lose its shape, the lead should be hammered or melted back into place with a blow-torch.

When the fluid in the pump must be removed the pump should be kept in an upright position until the volatile liquids which have been caught in the water-cooled trap on the side arm have been removed through the drain tube on this trap. The main body of the pump fluid can then be removed without danger of contamination from the material caught in the trap and should be preserved in a brown glass-stoppered bottle for future use. To avoid decomposition of the pump fluid, before exposing the pump to pressure above 1 mm. of mercury, allow the pump to cool to the point at which the vapors cease to be evolved from the boiler in large quantities. A ten to fifteen minute cooling period should be sufficient.

Used oil should be removed by rinsing the casing three or four times with acetone. With the caps removed from the two drain tubes, the acetone residue should then be removed completely by a blast of warm air.

c. The gears of the valve block, indicator dial, and stage movement should be lubricated with Lubrico grease, at intervals of from six months to a year.

d. The oil-impregnated rubber bushings which make the vacuum seals where motion must be transmitted into the microscope column should be lubricated every month. The recommended lubricant is a mixture of ten to twenty parts octoil to one of graphite, thoroughly emulsified. The oilers to be filled are located in the following places:

1. Camera cassette control knob.
2. Camera cassette movement gears.
3. Diffraction stage.
4. Stereo door.
5 and 6. Specimen stage movement.

e. All wire around controls on the control panel should be cleaned periodically, using solvent and crocus paper.

The following items should be taken care of, if the operation of the instrument indicates that it is necessary:

a. The gun filament must be replaced in case it burns out or when it has been used so long that a high beam current is obtained when the filament current is low, and the intensity is hard to control.

b. If the image jumps and drifts about it is an indication of dirt in the column. The pole pieces should be cleaned. If the image continues to jump there may be dirt in the specimen holder, the condenser aperture may need cleaning, or the objective aperture may have to be replaced.

c. If a gradual loss in resolution is observed, it is probably an indication of an accumulation of dirt around one of the apertures.

d. The fluorescent material on the viewing screens must be replaced if it is damaged.

e. It may be necessary to clean the ionization gauge occasionally. This is done with hot caustic soda. THE MAIN POWER AND THE PANEL LIGHTS SHOULD BE TURNED OFF BEFORE HANDLING THE GAUGE. Access to the gauge can be had when the table top is removed. The gauge is held to the column by four Allen head screws, and the electrical connections are made by two insulated cap leads.

FILTER DRIER

The air which is let into the column is dried and cleaned by passing it through the air filter which is located in the right-hand side of the microscope cabinet. The cleaning is accomplished by the felt pads at the end of the filter. About once a year these should be cleaned thoroughly with a blast of air or replaced. The air is dried with "Indicating Drierite" or anhydrous calcium sulfate. The dehydrated Drierite is blue; as it absorbs water it becomes rose colored. When the Drierite becomes rose colored up to the "change line," it should be replaced by dry Drierite or the pump down time of the microscope will increase because the Drierite is saturated with water vapor which can be drawn into the column. The Drierite can be regenerated by heating in an open pan, in an oven or on a hot plate, at a temperature of from 200°C to 250°C (572°F). The Drierite should be agitated during the heating process because the water is released from the upper surface.

ROUTINE CARE—In order to obtain the best performance of the electron microscope, a certain amount of routine care is necessary. A preliminary check of the instrument should be made. In the course of routine inspection, the following items should be checked as suggested:

a. The most important factor is cleanliness. The microscope column, chassis and rotary pumps should be dusted. Foreign matter in the column may prevent the pumps from attaining the proper pressure, or produce image distortion due to electrostatic charges. Dust will contaminate the specimens, and cause defects in the photographic plates. The high voltage unit must be clean in order to prevent arcing or brush discharge.

b. Test all tubes periodically and replace those in which the mutual conductance value falls below 70 per cent of the initial value. The tube tester used should reveal operating characteristics such as mutual conductance, amplification factor, etc.

c. All "B" batteries (45 volts) should be tested at least once a week and any one should be replaced when its voltage falls below 42 volts. The total nominal voltage of the series of batteries located in the battery box on the left door is 382½ volts. Caution should be exercised in testing these batteries to avoid being shocked.

d. The test meter should be checked by adjusting the range switch to its various positions and comparing the results obtained with the normal meter readings tabulated at the end of the section on "Operation."

e. The corona shields and high voltage parts should be kept highly polished at all times.

SERVICING—The following section is given to a discussion on (a) care of rotary pump, (b) checking for vacuum leaks, (c) replacement of gun filament, (d) cleaning of pole pieces, (e) cleaning of apertures.

Care of the Pump

When the mechanical pump is turned on, check to see that the oil level is correct and that no oil has backed up into the pump line as far as the stop-cock. Detailed directions for the care of the pump are given on the name plate on the pump.

The motor should be lubricated regularly in accordance with the Cenco instructions for the pump. The pump should be operated with recommended Cenco Hyvac light grade vacuum pump oil. The oil level should be kept mid-way between the two lines of the oil level indicator. It is best to check the oil level while the pump is running.

Checking for Vacuum Leaks

The following procedure is given to facilitate the location of leaks. A diagram of the entire vacuum system (M-427490) including pumps, valves, and gauges, as well as the implied functions of each is shown in Figure 6B. The technique of leak hunting and trouble shooting can be made much easier and much labor can be avoided if this vacuum system diagram is kept in mind and used as a step-by-step guide for trouble isolation.

If the microscope should fail to pump down to the operating pressure in about 15 minutes (after a 12-hour stand) time, the following points should be checked before beginning a systematic search of the microscope column.

a. Be sure that both the fore pump and the diffusion pump are operating.

b. If the proper fore pressure cannot be obtained with the valve block in "load," the trouble must be with the fore pump or a leak in the fore line, valve block, or diffusion pump.

c. Any joints which can be mechanically disturbed, such as the fore line, cassette control and stage movement controls should be checked to see if movement changes the pressure reading.

d. All joints which are held by screws should be checked to see if tightening the screws changes the pressure reading.

e. All seals which are made by oil impregnated rubber bushings should be lubricated with octoil and graphite to see if any change is made.

When it is fairly certain that a small leak is confined to a known section of the microscope, castor oil can be applied sparingly to the various parts of the isolated section until the leak is discovered, at which time the gauges will indicate a decrease in internal pressure. A common and practical method of testing for small leaks involves the use of a 4-oz. atomizer filled with ether. All joints and surfaces are sprayed until there is an indication that the internal pressure has increased. Ether, having a high vapor pressure, seeps readily through the perforation fault, and gives an immediate indication of increased pressure. Hydrogen gas is as effective as ether, but not generally as easily available and involves explosion hazards unless severe caution is exercised. Acetone is also an effective substitute for ether, but unfortunately it is a solvent for the baked-on finish of the microscope. Large leaks, generally, must be found by dismantling the microscope column section by section. As each section is removed, the exposed openings of the remaining part of the column must be temporarily sealed and the vacuum test continued. Temporary seals can be made from thin pieces of neoprene or sulfur-free rubber sheets held in place over the exposed openings by the weight of suitable metal plates. After isolation, the perforation fault of an offending section can be readily found by one of two methods. In the first method, the section is sealed off by means of clamps, gaskets, and gasket plates, with the execution of an orifice where air pressure (2 or 3 pounds) can be introduced. The bubble stream appearing when the section is submerged in alcohol, with the air pressure applied, gives an immediate clue to the source of the leak. Alcohol is used because of its low surface tension and freedom from trapped gases in the form of bubbles. In the second method, the same procedure is used except that, instead of alcohol immersion, the section is painted with soap bubbles. The source of the leak, of course, is the point at which new bubbles are constantly appearing within the lather.

In dismantling and reassembling the microscope vacuum system, the following precautions are very important:

a. Diligently label all screws, washers, gaskets, etc., so they can be returned to their original positions.

b. Be careful not to damage or mar gasket seats. Any damage may result in leaks.

c. Do not expose the microscope interior or inner parts to atmosphere and particularly to dust for any longer period of time than absolutely necessary. Dust particles, lint, etc., can pick up electrostatic charges from the electron beam and seriously interfere with the quality of the final image. This is particularly true of dust particles which settle on the apertures or inner configuration of the pole pieces. Electrostatically charged foreign particles can cause the final image to move continually or to oscillate. These phenomena, however, are distinct from image drift caused by electrostatic charges taken up by certain types of specimens, and for which, at present writing, there is no certain cure.

When the microscope is reassembled after some parts have been subjected to water, alcohol, or other substances, it will be found that the pump-down time to remove gases may be an hour or longer. However, from this point on, provided that the system is tight and no further contamination other than routine is permitted, pump-down time will shortly reduce to a point where, with a hot diffusion pump, not more than 1 to 3 minutes will be required to reach operating pressure from a standing-still sealed-off period of 12 hours.

Gaskets

Since the column of the microscope must be evacuated before the instrument can be put into operation, it is necessary for all joints to be vacuum tight. The following points should be observed in the preparation of gaskets and assembly of the column:

a. Gaskets can be cut by using a compass, a phonograph needle on a flying arm attached to a drill press, or a sharp knife. Water is a satisfactory lubricant.

b. All gaskets should be inspected for defects, such as holes in the edge, soft spots and irregularities in thickness. These can sometimes be detected by stretching the gasket. If necessary, the flat surface should be ground on a #200 abrasive paper. A gasket can be checked for flatness by putting a small amount of Celloseal on it, pressing between two glass plates and observing to see if it makes contact all the way around.

c. All gasket seats should be carefully polished with a #200 abrasive followed by crocus cloth, to remove radial scratches. Very small scratches are especially to be avoided, since the rubber, although under pressure, cannot seal scratches. The gasket seats should be perfectly clean in order to insure a tight seal.

d. To cement a gasket in place, use Reanite 111K or Cycleweld cement. The gasket should be clamped in place and vulcanized in an oven for about half an hour.

e. Where motion is to be transmitted into the vacuum chamber, the seal is made by a rubber bushing surrounding the shaft and impregnated with octoil and graphite. The recommended mixture is about ten to twenty parts of octoil to one of graphite, thoroughly emulsified.

f. Gaskets which are not cemented in place should have a small amount of Celloseal rubbed onto the surface. This softens the gasket material and acts as a cement.

g. When the column is assembled it should be checked after each unit is added, by blocking off that unit with a gasket and flat plate and checking to see if it will pump down. Considerable time will be saved in locating the trouble if there should be a faulty gasket or some other leak.

REPLACEMENT OF COATING ON FLUORESCENT VIEWING SCREENS

Fluorescent material, ZnS-CdS-2272 (1-oz. bottle Stock No. 47656) is available for coating screens used in the electron microscope. The material has a brilliant yellow fluorescence, is light yellow when viewed by daylight, has a finer particle size than the standard Willemite formerly used and produces three times the visible light given off by Willemite under the same electron bombardment. The color excited is in the region of greatest sensitivity of the eye.

Preparation

ZnS-CdS-2272 comes in the form of a fine powder which must be suspended in a volatile solvent for coating. It is recommended that 1 oz. of the material be suspended in 8 ozs. of acetone. This mixture must be stirred well in order to break up agglomerates of the fine particles. It may then be stored and used as necessary. The inclusion of a small amount of 2% parlodion solution (2% parlodion in amyl acetate as commonly used for specimen supporting films) tends to make the phosphor adhere more securely to the metal.

Application

The simplest method of coating the surfaces is to use a spray gun. A kit that has been found satisfactory consists of the following parts obtainable from the DeVilbiss Company, Toledo, Ohio:

1 type CH-502 Spray Gun with type C-625 Cap.
1 #90 Air Cap.
1 #902 Air Cap.
1 type H Fluid Cap.
1 type F Fluid Cap.
1 Connection H-601.
10 feet tubing type H1080.
2 C-625 Cups (6-oz, glass).
1 type C Suction Cup Feed Attachment.

These components permit a wide range of spray control, and the best combination for use can be found by experiment.

It is essential that the compressed air used to operate the spray gun be free of oil, water, and dust, as contamination of the fluorescent material seriously affects its performance. A Cenco Oil Separator and Air Filter #1395M or equivalent should give good results when inserted in the air line.

The best distance at which to hold the gun when spraying a surface is determined by the air pressure used and the rate of evaporation of the solvent. If the gun is held too close to the surface, droplets will form and a non-uniform coating will result. On the other hand, if the gun is too far away the solvent will evaporate too soon and the coating will not stick. A little practice will permit the correct technique to be determined.

If a finer, more uniform coating than can be obtained by spraying is desired, the surface may be covered by allowing the fluorescent material to settle on to the screen. For this process, the screen should be placed in an evaporating dish which is equipped with a stop-cock in the bottom. The well-dispersed suspension is then poured in, the dish covered, and the stop-cock opened so that the liquid may drip out slowly. A very uniform coating of small particles and concomitant high resolving power may be obtained in this manner. Such a coating is required only for the final viewing screen, however, as high resolution is not essential for the intermediate or gun screens.

As thin a layer of ZnS-CdS-2272 as practicable should be used on the gun and intermediate screens. The metal should still be visible through the coating. If too much of the phosphor is used, serious optical difficulties will arise because of the considerable electrostatic charge built up by the material. The final viewing screen should have a heavier coating, as it must be adequately covered in order to provide sufficient intensity and detail. However, an adequate coating is one which is just sufficient to completely cover the metal surface. Too heavy a coating may result in image distortion.

SOLDERING PROCEDURE

The following soldering procedure is particularly applicable to the repair and installation of bellows.

a. All surfaces requiring tinning must first be cleaned. Fine sandpaper and a solvent may be required.

b. Use zinc chloride as a flux. Do not permit any other flux to come in contact with the work. Keep soldering iron free from any other type of flux.

c. Immediately after tinning operation, thoroughly remove all traces of flux with hot running water.

d. Tinned surfaces which are to be joined to each other, should not be left unassembled for more than 24 hours.

e. When bellows attached to parts having large heat capacity must be replaced, heat the entire assembly on a hot plate until the old solder melts. The damaged bellows can then be removed easily and the new one installed. While the parts are still hot, a soldering iron should be used to smooth the seal and make a vacuum tight joint.

f. Wherever possible, avoid using flux when assembling or joining parts with tinned surfaces.

g. Where flux may be required in Item f, resin is recommended as the flux. All traces of resin should be removed with alcohol after soldering operations. Paint any new bellows with a thin coat of glyptal lacquer (General Electric #1202 glyptal and #1500 thinner) after it has been soldered and before installing it in the microscope, inhibiting corrosion and sealing any pinholes in the body of the sylphon or soldered joints.

REPLACEMENT OF THE ELECTRON GUN FILAMENT

In order to obtain sufficient emission for an adequately bright final image, it is necessary to run the electron microscope filament at a temperature which is considerably higher than that used in ordinary electronic tubes. As a result of this higher operating temperature and the relatively poor vacuum used in the microscope, the filament deteriorates rather rapidly. In operation, this deterioration becomes apparent by a change in the operating position of the filament control. As the filament becomes thinner, less heating current is required to heat it to the temperature at which the total beam current is 450 microamperes. As the filament is used, the position of the knob marked "FILAMENT," at which a total beam current as read on the "BEAM" meter registers 450 microamperes, will gradually recede to the left. Finally, it will be found that when the "FILAMENT" knob is turned counterclockwise as far as possible the beam current on the "BEAM" meter will be about 500 microamperes, and eventually will be sufficient to overload the high tension system and actuate the protective relay and "OVERLOAD" lamp. When this point is reached, the filament must be replaced. The procedure for replacing the electron gun filament is as follows:

The first step is to turn off filament, high voltage, and main power. Then, in order to gain access to the electron gun, the hood which covers the gun is pushed up until the supporting bracket locks into position. At the same time, the high voltage bushing is automatically grounded. To remove the filament assembly it is first necessary to disconnect the three leads passing through the tube from the bushing through the corona shield. The two leads with spade tips are freed by loosening the screw which clamps them, and the third lead to the center terminal of the gun is merely lifted off. Next the corona ring on top of the gun should be removed.

The valve control handle should then be turned until the valve block is in the "LOADING" position so that air is admitted to the column. The four screws on top of the electron gun are then removed and the filament assembly is lifted out, care being taken not to scratch the shield on adjacent parts.

The shield is now removed by unscrewing it and carefully sliding it off over the bellows and filament supporting block, thus exposing the filament. The two small Allen setscrews in the filament supporting block should then be loosened and the filament assembly, including the mica disc, is lifted out. This assembly should be saved, as new filaments can be spot-welded on to it. A new filament assembly is then placed on the block and clamped into position by tightening the Allen setscrews. The shield is now carefully slipped back over the filament and screwed into position. The tip of the filament should now be quite accurately at the center of the aperture in the shield. If this condition is not met, the aperture end of the shield should be unscrewed and the filament bent gently with a pair of forceps, until the tip is centered with respect to the aperture. The entire shield should now be wiped with a soft cloth or chamois which has been wet with alcohol, in order to remove any fingerprints, lint, or dust. By turning the worm gear at the top of the filament assembly, the height of the filament should be adjusted until the tip of the filament is nearly in the plane of the aperture, at which point the filament will be too low and, when the beam is turned on, the easily recognizable astroid pattern will be obtained on the gun screen. One precaution must be noted: In setting the filament too low be sure that the filament itself does not touch the shield, or it will cause a short circuit.

The entire filament assembly should now be reinstalled in the microscope, the steps being the same as those described for removing the filament, but followed in the reverse order. With the microscope pumped down and the beam turned on, the filament height should be adjusted as described in the section under "ALIGNMENT."

CLEANING POLE PIECES

a. Before attempting to remove the bellows and pole pieces, turn the crank handle on the right side of the microscope until the dial indicates "loading" position. Admit air into the column to reduce the pressure.

b. Slide back the cover over the opening to the objective chamber.

c. With the forceps provided for the purpose, grip the bellows and remove it.

d. With a spanner wrench, loosen the screw supporting the objective pole piece.

e. Lift out the projector viewing screen.

The objective and projector pole pieces require routine inspection and must be carefully cleaned to remove all traces of foreign material. Preliminary cleaning can be accomplished with a rinse in acetone or carbon tetrachloride and should be followed by hand drying with a clean chamois. A toothpick, or better still, a piece of orange wood can be used as a reamer to ream clean the sides of the hole. After this cleaning, the pole piece hole should be examined carefully with at least a 5x eyepiece. Particles still adhering can be removed with fine tweezers or the orange stick. Compressed air cleaning is not recommended because of the dirt particles inherent in the blast. After cleaning, the pole pieces should be protected from dust if they are not to be used in the microscope column immediately.

The prime cause of image movement in micrographs is dirt or lint in the confines of the pole pieces, apertures, specimen holder, etc. Too much care cannot be given in insuring cleanliness

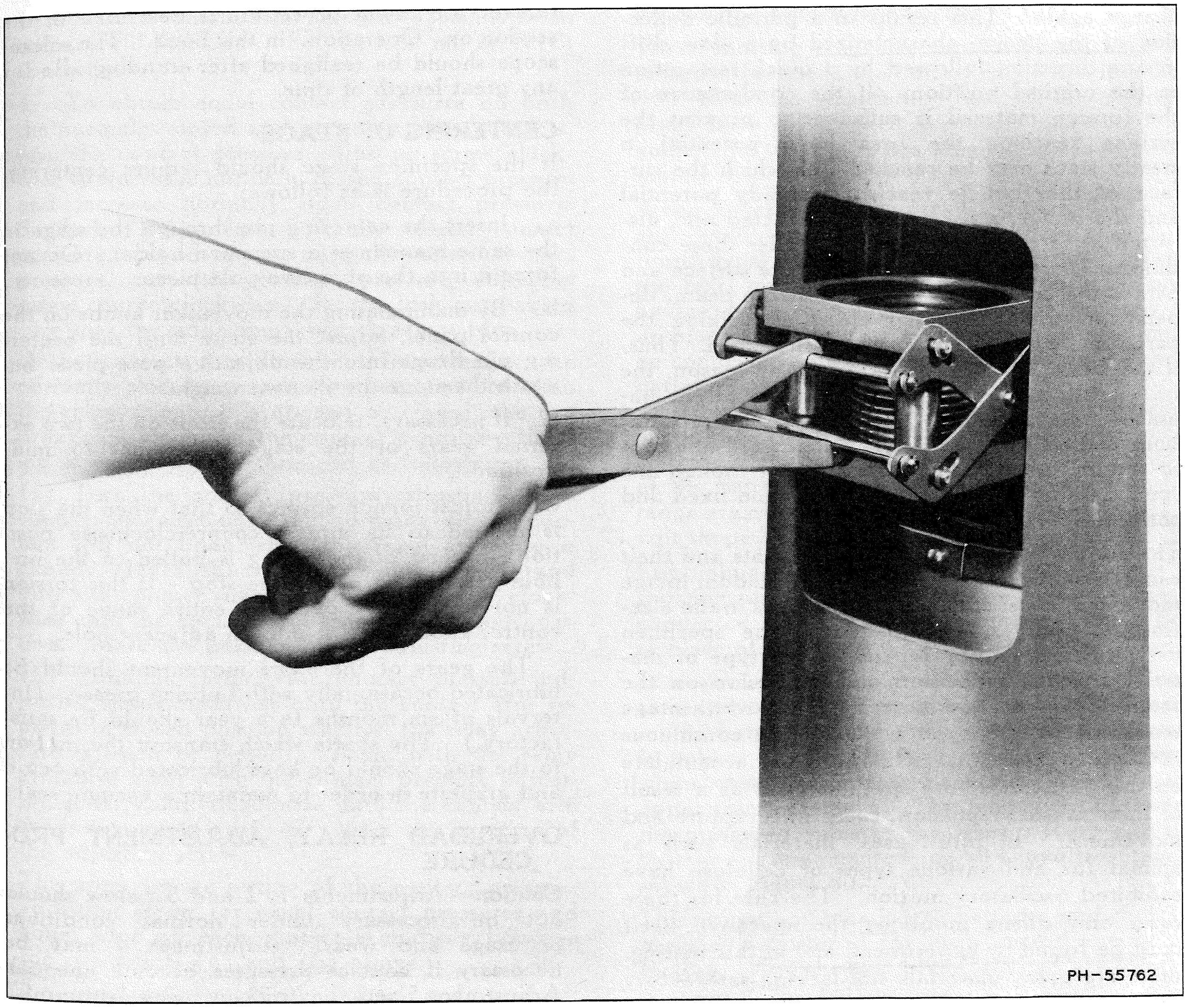


Figure 15—Installation or Removal of Bellows in Intermediate Tube

in these accessories. Fixed images also depend on column alignment. A properly aligned column produces image rotation only, as lens currents are varied. Changing the beam current in an aligned column having constant accelerating and lens voltage is equivalent to changing the quantity of illumination and should not produce image movement unless there is dirt in the system.

Any foreign material in the confines of the optical system will assume electrostatic charges from the electron beam. If the foreign material is in the form of an insulating or semi-insulating particle or film, the charge accumulation will raise the potential of its surface. The field produced between this charged surface and the microscope column will deflect and distort the electron beam. If the foreign material is a good insulator its surface may charge to such a potential that the insulation breaks down suddenly and the charge disappears. At the same time, the potential between the surface of the material and the microscope column also disappears. Immediately, the surface of the foreign material will begin to charge again. This results in a periodic deflection of the image, characterized by a slow drift in one direction followed by a quick restoration to the original position. If the conductance of the foreign material is sufficient to prevent the surface reaching the breakdown potential, a steady state may be reached, for which the surface of the particle reaches a steady potential and the image is permanently deflected and distorted by a constant amount. Under these conditions, however, the potential of the surface and hence, the amount of deflection of the beam, depend on the number of electrons striking the particle, i. e., on the intensity of the beam. Thus, if the beam intensity changes for any reason, the image will move accordingly and result in unusable micrographs. Likewise, the lens aberrations caused by these spurious fields are sufficient to render micrographs inferior even though the spurious field potentials tend to remain fixed and constant.

The above-described image movements and their causes are not to be confused with random image movement caused by possible changes in the electrostatic charges accumulated in the specimen itself. These effects depend on the type of material and its disposition and dispersion on the supporting film and screen. However, image movement of this type is quite often continuous in a given direction. Charges then accumulate on the particles of the specimen and as a result of their mutual repulsion, cause film rupture and movement. In rare cases, materials such as animal fur and various types of cellulose have exhibited oscillatory motion. The cure for these cases and others involving the specimen itself must be found by experiment, and at this writing, there are many materials still lacking satisfactory "quieting" techniques.

To replace bellows and pole pieces, reverse the order in which they are removed.

APERTURES

If an objective aperture is used, it should be as close to 0.001″ diameter as possible. An objective aperture will enhance resolution and contrast for some types of specimens.

Electron optical components of the column (including apertures) not covered in the above instructions can be cleaned by employing solvent, chamois, orange stick and distilled water as best suits each condition. Parts which are coated with fluorescent materials should be carefully handled to avoid damage. The edges of the holes of the primary intermediate screens should be freed of fluorescent material inasmuch as this material is highly electrostatic. The pointed end of a toothpick will remove fluorescent material at the surface edge while the body and end of the toothpick can be used inside the hole.

REALIGNMENT OF THE MICROSCOPE—

After having replaced the objective aperture, or after reassembling the microscope column, the entire microscope must be realigned. The systematic alignment procedure is described in the section on "Operation" in this book. The microscope should be realigned after standing idle for any great length of time.

CENTERING OF STAGE

If the specimen stage should require centering, the procedure is as follows:

a. Insert the centering pin through the stage in the same manner as a specimen holder. Do not force it into the objective pole piece.

b. By manipulating the movement knobs on the control panel, adjust the stage until the centering pin drops into the objective pole piece beneath the stage, by its own weight.

c. If necessary, relocate the stops on the two external gears of the stage movement to mid-position.

d. Adjust torsion springs so that when the stop is rotated to its utmost counterclockwise position, the end of the spring is pulled to the first hole past the corner of the stop. If this torsion is not satisfactory over the entire range of the control knob, hook it into an adjacent hole.

The gears of the stage movement should be lubricated occasionally with Lubrico grease. (Intervals of six months to a year should be satisfactory.) The shafts which transmit the motion to the stage should be kept lubricated with octoil and graphite in order to maintain a vacuum seal.

OVERLOAD RELAY, ADJUSTMENT PROCEDURE

Caution—Adjustments 1, 2 and 3 below should not be necessary under normal conditions of usage and wear. Adjustment 4 may be necessary if contact pressures become unequal. Adjustment 5 sets the "pick-up" and "drop-out" currents and such adjustment may be necessary at time of installation. In general, adjustments should be made in order listed, if necessary. For example: If adjustment 2 is necessary, adjustments 3, 4 and 5 should be checked and readjusted, if necessary, after adjustment 2 is made.

1. Closed Air Gap Adjustment—With the relay armature in closed position, adjust the anti-freeze pin by inserting a .005″ feeler gauge between the relay armature and the edge of the pole face nearest the hinge while turning the pin clockwise to open the gap, or counterclockwise to close the gap until the gauge just clears. Then set the lock nut on the anti-freeze pin.

2. Open Air Gap Adjustment—With the relay armature in open position, adjust the armature limit pin by turning the pin clockwise to close the gap, or counterclockwise to open the gap until a .012″ feeler gauge between the pole face and anti-freeze pin will just clear. Then set the lock nut on limit pin.

3. Adjust the contact gap with the relay armature open by turning the normally closed contact pin clockwise to close the gap, or counterclockwise to open the gap until a .015″ feeler gauge between the contact armature and normally open contact will just clear. Set the lock nut on N. C. contact pin.

4. To obtain equal contact pressures on both the normally closed and normally open contacts, turn the contact pressure adjusting screw clockwise to decrease normally closed contact pressure and increase normally open contact pressure. Similarly, to increase normally closed contact pressure and decrease normally open contact pressure, turn the contact pressure adjusting screw counterclockwise. Set the lock nut, taking care that the adjusting screw does not turn.

If the contact arm does not leave either the normally closed or normally open contacts when the relay armature is opened or closed, the approximate setting of the contact pressure adjusting screw may be determined as follows:

(a) Turn the contact pressure adjusting screw counterclockwise until the normally closed contact will not open when the relay armature is closed. Hold the relay armature closed and turn the contact pressure adjusting screw clockwise until the contact arm snaps into closed position. Mark the position of the adjusting screw.

(b) Continue turning the contact pressure adjusting screw clockwise until the contact arm remains in closed position whether the relay armature is open or closed. Then, with the relay armature open, turn the contact pressure adjusting screw counterclockwise until the contact arm snaps into open position. Mark this position of the adjusting screw.

The approximate setting of the contact pressure adjusting screw for equal contact pressures and equal wipe on each contact is midway between the two points (a) and (b) above.

5. Final adjustment of pick-up and drop-out current values is obtained by turning the elastic stop nut on the relay armature compression spring. To increase pick-up current and decrease drop-out current, turn the nut clockwise. Turning the nut counterclockwise decreases pick-up current and increases drop-out current.

6. The relay must operate on .70 to .75 ma. After operation, the relay must drop out on .20 to .30 ma.

7. The pressure between the contact arm and either contact must be 4+ grams.

ADJUSTMENT OF 50 KILOVOLT SUPPLY

The high voltage may be adjusted to 50 kilovolts by setting the total voltage from the bank of eight 45-volt batteries plus a 22½-volt tapped battery. These batteries, B-1 to B-9, are located in the battery box on the left-hand door of the cabinet. In steps of 1½ volts, the battery voltage may be varied from 382½ volts to 282½ volts. Voltages between 382½ and 360 volts are obtained by moving the connections on the tapped battery, B-9, in the top right corner of the battery box. The proper battery voltage is determined by the resistance of the high voltage feedback resistor, R-65, and is adjusted for each microscope before leaving the factory.

Three shorting plugs are provided with each instrument for use in the battery box when less than 360 volts are required. Two of the shorting plugs have all of their terminals connected together, the third plug has a pair of leads approximately 3 inches long.

When a battery box voltage between 360 volts and 337½ volts is required, the battery B-8, fourth from the bottom on the righ-hand side of the box, must be removed. The shorting plug having two leads must be inserted securely in its place, and the two leads from the plug must be connected to the two terminals of a 22½-volt battery (similar to B-11). The correct polarity must be observed, and may be obtained by connecting the red lead to the positive (+) terminal and the black lead to the negative (−) terminal of the battery. Variations in voltage within the range are obtained by adjusting taps on the 22½-volt tapped battery, B-9.

For voltages from 337½ volts to 315 volts, a shorting plug of the type having all its terminals connected together is inserted in the battery box in place of battery B-8.

In a similar manner, remove batteries B-7, etc., as may be required, to adjust the output voltage of the battery box to the lowest value necessary to deliver 50 kilovolts from the high voltage unit, when resistor R-65 may have a resistance at the upper tolerance limit. The relationship between the measured value of the resistor R-65 and the battery voltage required for 50 kilovolts output is shown in Figure 80.

The proper combination of batteries and shorting plugs is determined for each microscope in the factory. Any shorting plugs required are shipped in place in the battery box. Any shorting plugs not required at the time the instrument leaves the factory are shipped with the accessories to the microscope. Battery replacements should be madew ith the same combination of batteries and shorting plugs as those supplied with the instrument. It is recommended that complete battery replacement be made approximately every six months for optimum performance of the microscope.

A change in the output voltage of the battery box should be necessary only if the high voltage feedback resistor R-65, has been replaced.

TOUCH-UP ENAMEL KIT

Under this title is comprised a kit including the various paint finishes used on the electron microscope. The kit is made up of the following items:

1. One 1-pint can of enamel, Fin. No. 701 (light cobalt gray).
2. One 1-pint can of enamel, Fin. No. 702 (dark cobalt gray).
3. One 1-quart can of thinner, RCA No. 3.
4. One packing list.

Items 1 and 2 (Finishes Nos. 701 and 702) are applied on the microscope column and outer cabinet surfaces. Item 1 (Finish No. 701) is employed on the interior of the cabinet and other inside parts. These finishes are used with one part of RCA No. 3 thinner for the first or prime coats. For second or touch-up coats, they may be used without a thinner.

The thinner is highly inflammable and should not be used near an open flame. Sufficient ventilation must be available at all times during its use. For best results, Finishes Nos. 701 and 702 may be sprayed in covering large areas. Small areas and marred surfaces can be touched up with a soft brush.

All outside finishes can be protected and improved through application of Simonize wax or equivalent.

METHODS OF PREPARATION OF THE SUPPORTING MEMBRANE AND THE SPECIMEN ITSELF

Casting—In this method the materials from which the membrane is to be made is dissolved in a volatile solvent. A drop of this solution is placed on the surface of a suitable liquid. A satisfactory choice for this liquid is one in which neither the membrane material nor the solvent will dissolve, and which has a higher surface tension than the solution. When a drop of the solution is placed on the surface of the liquid the difference in surface tension allows the drop to spread over a considerable area. This exposes a large area to the air thus allowing the solvent to evaporate quickly, leaving a thin solid film on the surface of the liquid. This film may then be mounted by the method described below.

Dipping—This method is particularly applicable to the observation of the structure of the films themselves. Merely dip the screen specimen holder into a dilute solution of the material, remove it, and allow it to drain and to dry. After the concentration of the solution has been properly adjusted and the process carried out in a standardized manner, it is possible to produce, across the opening of the specimen holder, extremely thin films suitable for observation with the electron microscope.

Stripping—This method was first developed for electron diffraction work. A solution of the materials from which the membrane is to be made is coated on the surface of a specially cleansed piece of glass. Once again the solvent used must be volatile. Before the solvent evaporates, the thickness of the layer on the glass is made extremely uniform by spreading the solution by means of a special gauge. This gauge usually consists of a razor edge mounted so that when it is passed over the glass surface there is a constant spacing between the edge and the surface of the glass plate. This thickness is adjusted so that when the solvent evaporates, a solid film of the desired thickness will be left on the surface of the glass. A heavy frame of the material is then painted around the thin film area so that a fairly substantial edge is provided which helps in the stripping process. Loosen one side of the thick edge of the film and lower the glass plate obliquely into clean water, film side up.

If the glass and water surface have been properly cleansed, the film will float off onto the surface of the water. It may then be mounted by one of the methods described below.

In the following description of the various types of preparation technique, the method by which the preparation is mounted on the screen specimen mount will be mentioned. However, owing to the extreme importance of one of these methods, this one will be described in detail. This method will be referred to in the following as the mounting of a cast film. In particular, the type of film prepared will be collodion.

A well-filtered solution of collodion in amyl acetate (2% collodion) is drawn up into an eyedropper and a single drop placed carefully on the surface of well-distilled water. For the concentration of the solution mentioned above, the water surface should be at least 20 centimeters in diameter, preferably circular, while the drop size should be of the order of 1.5 millimeters in diameter. On reaching the water surface, the drop spreads over a fairly large area and the amyl acetate evaporates leaving the desired film of collodion floating on the surface of the water. During the process of spreading and evaporating, interference colors can be seen in the film and can be used as a check on the quality of the film to be obtained. Such interference colors should appear either uniform over the whole of the surface of the film or in fairly uniform broad circles. In the last stages of drying the thickness of the film is much less than the minimum which will give interference colors. However, when the drying is completed, the remaining film may be detected by a difference in the sheen of the water surface. Moreover, a good film appears to be surrounded by a very narrow corrugated

edge. The edge of the film should, of course, be approximately circular if the spreading took place uniformly. By measuring the diameter of the film on the surface of the water, it is possible to calculate the thickness, if the size of the original drop and the concentration of solid material in that drop are known.

After a film has been obtained on the surface of the water, a number of screen discs are placed around the surface. These are picked up in the circular loop from below. In order to leave all of the film except the part being used undisturbed, a needle is run quickly around the edge of the loop, thus cutting out that portion of the film. As it is lifted out of the water, the wire loop carries the screen disc supported in its opening on the collodion membrane and a certain amount of water which still adheres to the lower side of the membrane and the loop. The screen disc is inverted and passed over one of the small cylinders. A pair of forceps is now used to lift the cylinder up through the loop so that the latter may be taken off the bottom. After this operation, the screen disc rests on top of the cylinder and is completely covered by the collodion membrane, upon which there usually adhere a few drops of surplus water. The surplus water is then drawn off immediately by means of a micropipette. As water does not readily wet collodion, the extra drops of water drawn off in the manner described above, come off very completely and take all foreign material either in the water or on the surface of the drop with it. The specimen mount is then ready for the addition of the specimen, or, if the preparation is of the kind where the specimen is imbedded directly in the collodion itself, is ready for observation in the electron microscope. Films prepared in this way have been found to be extremely clean and do not possess any structure of their own.

Alternate Method for Screen Film Preparation—An alternate method for preparing the screen films is described below. This is simpler than the method set forth in the preceding paragraphs, and does not require any special tools to be used.

a. In the same manner as explained in the first column of this page, prepare a thin film of collodion on the surface of well distilled water contained in a vessel at least 20 centimeters in diameter. The vessel should be filled with water up to a level of about three to four inches.

b. Place 6 or 8 screen discs on the film surface along two parallel rows. The discs in each row as well as the two rows themselves should be about ¼ inch apart from each other.

c. With a clean tool, gently press down each disc so that the collodion film will adhere to the screen mesh of the discs.

d. Taking a very clean microscope slide, hold this vertically over the surface, with one of the small edges at the bottom, about ¼ inch from the end of the two rows of discs.

e. Then move the slide downward into the water. The collodion film on the water surface will thereby be pushed down, fold up around the bottom edge of the slide, and apply against the face of the slide, to which it will adhere. The screen discs, in this manner, find themselves between the face of the glass slide and the collodion film.

f. Pull the slide upward vertically out of the water, drain off the excess water by holding the bottom edge of the slide against a clean piece of cloth or blotting paper. Then allow the slide to dry about 5 minutes.

g. The collodion coated screen discs may now be removed from the slide and are ready for use.

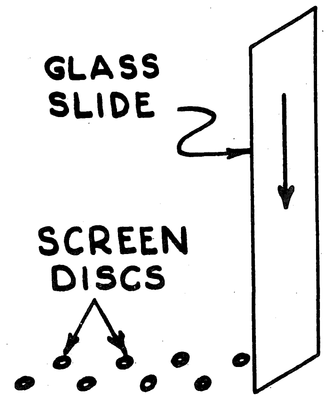


Figure 16—Screen Film Preparation
(*K*-885394—*Sub.* 0)

PROBLEMS ASSOCIATED WITH THE PREPARATION AND OBSERVATION OF ELECTRON MICROSCOPE SPECIMENS

There are a number of difficulties which must be overcome in order to obtain a successful electron micrograph of any particular material. The first of these includes those difficulties encountered in the actual preparation of the specimen. The second group includes those effects which result in the destruction of the supporting membrane of the specimen during observation. The third group includes the difficulties being encountered due to the effects of the electron beam on the specimen itself.

In the preparation of a specimen for the electron microscope, one of the first difficulties encountered is that due to the presence of impurities. The instrument is capable of detecting such minute quantities of materials, that impurities which exist in concentrations of only one part in several million can easily be detected. In the case of specimens of approximately known characteristics, such impurities are not of any great importance since they may be easily recognized for what they are. On the other hand, if the investigation is to be carried out with materials of unknown properties, the impurities present must be either eliminated completely or identified in order that they may be recognized in subsequent work.

It is, of course, essential that the mounting membranes be absolutely free of any structure due to impurities in the materials used or to faults in the forming process. The most important difficulty to be found in the preparation of specimens from a liquid dispersion, is due to the surface tension of the liquids used. This effect is particularly annoying if the surface tension is such that the liquid does not wet the collodion, for, in this case, the liquid, upon drying, will gather in droplets around the larger particles of the specimen. It is exceedingly difficult to get an even distribution of the specimen material under such conditions. The difficulty can often be overcome by using one of the other methods of preparation.

Other phenomena which must be kept in mind in connection with this type of specimen, particularly when an aqueous suspension is used, are those due to changes in pH. with drying, changes in concentration with resulting changes in osmotic effects, and fractionation due to size selection by the method of preparation.

One of the most common effects encountered in the observation of specimens which contain some larger particles or groups of particles is the rupture of the supporting membrane due to electrostatic forces. Owing to the fact that the supporting membrane is an excellent insulator, any charges which appear on the surfaces of larger particles due to the absorption of beam electrons tend to build up until appreciable potentials are reached. Such particles will be repelled by neighboring particles with a force strong enough to rupture the supporting membrane. Successful micrographs can seldom be made of specimens that have been ruptured in this way because they seldom reach an equilibrium state which is independent of beam intensity.

A second effect that may cause a membrane to rupture is the heating of particles by the absorption of beam electrons to temperatures above the melting point of the material of which the film is made. As in the preceding case, this phenomenon occurs only in presence of large particles. A cure for both difficulties may be found by eliminating the larger particles from the specimen.

When it is necessary to obtain a micrograph of a specimen which consists mainly of larger particles, it is often possible to use a low intensity illuminating beam and photographic focusing.

The effect of the electron beam itself on the specimen may appear in the electron image in a number of ways. These include the effects which are due to heating of the specimen, decomposition due to heat and excitation from the electron beam, evaporation in the vacuum and under the excitation of the electron beam, and finally, the killing of living specimens.

Since these effects are varied and have as yet not been studied in detail, no more can be done here than to mention them and call them to the attention of the research worker who may be interested in investigating some specimen in which one or more of these effects occur.

SERVICE PARTS LIST
RCA ELECTRON MICROSCOPE
EMU-1

MAIN ASSEMBLY

Symbol No.	Stock No.	Description	Dwg. No.
A-6	48495	Clock	
S-1A-1B S-2A-2B S-17A-17B S-18A-18B S-10A-10B	48337	Interlock Switches (male and female section)	
V-12	47744	Thermocouple Gauge	427435-1
X-40 X-41	48254	Connector—Male for condenser and obj. coil	878441-1
		DIAL ASSEMBLY	
	48478	Crystal—Dial	890381-1
	48479	Dial	24670-1
	48480	Pointer	890380-2
	48481	Spring	718955-27
		INTERMEDIATE VIEWING SCREEN HOUSING	
	47751	Housing—Intermediate viewing screen (complete)	878516-501
	47127	Gasket—Intermediate viewing screen window	613792-41
	47753	Gasket—Intermediate viewing screen housing gasket	613792-24
	47752	Ring—Window retaining	870448-2
	47754	Screen—Intermediate viewing housing	859388-2
	47129	Window—Intermediate viewing screen	870447-1
	49022	Aperture—Pole piece aperture	886416-1
	47760	Bushing—Control knob bracket	878754-1
	47695	Cable—Grounding	891403-501
	47761	Collar—Control knob bracket	891401-1
	47996	Cushion—Column end piece	891197-1
	47997	Cushion—Column shock mtg.	891197-2
	47742	Cushion Assembly—Column	891199-501
	47745	Gasket—External manifold	613792-59
	48003	Hose—Dehydrator to valve	891102-2
	47746	Hose—Vacuum pump	891132-3
	47748	Hose—Water	891102-1
	48016	Knob—Stage control	891467-501
	48796	Magnifier	427459-501
	47757	Manifold—External	427268-501
	48797	Manifold—Internal (cond. coil—specimen chamber)	890331-501
	48453	Bellows—Internal manifold bellows (condenser coil to specimen chamber)	890333-1
	47753	Gasket—Internal manifold gasket	613792-24
	48452	Spring—Internal manifold spring (condenser coil to specimen chamber)	427496-2
	48798	Manifold—Internal (obj. coil—interviewing screen housing)	427248-501
	44052	Bellows—Internal manifold bellows (obj. coil to inter. screen)	859962-2
	47753	Gasket—Internal manifold gasket	613792-24
	47755	Head—Internal manifold head (obj. coil to inter. screen)	878509-1
	47756	Spring—Internal manifold spring (obj. coil to inter. screen)	718955-23
	44116	Mounting—Lord—Rear column support	834180-7
	47749	Screen—Intermediate viewing	878488-1
	47922	Shaft—Flexible—Dial indicator	891396-1
	47921	Shaft—Flexible stage control	427237-501
	47758	Spring—Primary viewing screen	891161-1
	47747	Stop Cock—Glass (3-way)	427444-1

CONTROL PANEL ASSEMBLY 613738-501

Symbol No.	Stock No.	Description	Dwg. No.
		UPPER CONTROL PANEL 613736-501	
A-1 to A-4	31480	Pilot Lamp—6-8 v.	61114-22
C-15	18416	Capacitor—1.0 mfd., 150 v.	72043-533
R-11	3058	Resistor—100,000 ohms, 1 w.	78728-86
R-12	48184	Resistor—750 ohms, 10 w.	427230-34
R-13	48185	Resistor—41.6 ohms, 1 w.	891402-6
R-22	48809	Resistor—6,000 ohms, 25 w.	427230-22
R-23	48192	Resistor—400 ohms, 20 w.	878434-1
R-24	39380	Resistor—27 ohms, 1 w.	78728-43
R-26	48193	Resistor—800 ohms, 25 w.	427230-31
R-27	Same as R-26		
R-57	30495	Resistor—47,000 ohms, 1 w.	78728-82
R-61	48194	Resistor—4 ohms, 1 w.	891402-2
R-66	48209	Resistor—2000 ohms, 25 w.	427230-32
R-71	Same as R-26		
R-72	48771	Resistor—1 meg., 1 w.	891029-5
R-73	Same as R-26		
R-100	48192	Resistor—400 ohms, 20 w.	878434-1
S-3, 4	48904	Switch—Panel lights and main power DPST	878368-5
S-5	48238	Switch—Cond. OFF	427246-1
S-7	47118	Switch—Diff. OFF proj.	427247-1
S-8	48905	Switch—H.V. SPST	878368-4
S-11	48240	Switch—Test	427472-1
S-12	48238	Switch—Off. obj.	427246-1
S-13	48906	Switch—Room lights—SPDT	878368-6
V-9		Neon Indicator	RCA #991
V-25	Same as V-9		
X-1	48250	Socket—V-9	878367-2
X-2	48250	Socket—V-25	878367-2
X-4	34449	Socket—A-1	39026-505
X-5, 6, 7	Same as X-4		
X-68	43377	Socket	844041-505
X-69	48253	Socket	891473-1
X-70	48259	Socket	878746-3
X-71	43377	Socket	844041-505
	28000	Knob	717296-503
		LOWER CONTROL PANEL 613737-501	
M-1	46028	Meter—Fore pressure	426590-2
M-2, 3	46030	Meter—Column pressure	426590-4
M-4	46032	Meter—Test	426590-6
R-19	48188	Rheostat—1000 ohms, 25 w.	415457-23
R-21	48190	Rheostat—18,000 ohms, 50 w.	878370-2
R-25	48188	Rheostat—Diff.—Focus	415457-23
R-63	48207	Resistor—3300 ohms, 10 w.	878435-13
R-64	48208	Rheostat—10,000 ohms, 50 w.	878370-3
R-70	48210	Rheostat—8000 ohms, 50 w.	878370-1
R-74	48211	Resistor—250 ohms, 10 w.	878435-2
R-75	48212	Resistor—14 ohms, 1 w.	891402-13
R-76	48213	Resistor—16 ohms, 1 w.	891402-14
R-77	48214	Resistor—18 ohms, 1 w.	891402-15
R-78	48215	Resistor—20 ohms, 1 w.	891402-5
R-79	48216	Resistor—23 ohms, 1 w.	891402-16
R-80	48217	Resistor—26 ohms, 1 w.	891402-17
R-81	48218	Resistor—30 ohms, 1 w.	891402-18
R-82	48219	Resistor—36 ohms, 1 w.	891402-19
R-83	48185	Resistor—41.6 ohms, 1 w.	891402-6
R-84	48221	Resistor—51 ohms, 1 w.	891402-20
R-85	48222	Resistor—63 ohms, 1 w.	891402-21
R-86	48223	Resistor—79 ohms, 1 w.	891402-22
R-87	48224	Resistor—103 ohms, 1 w.	891402-23
R-88	48225	Resistor—137 ohms, 1 w.	891402-24
R-89	48226	Resistor—198 ohms, 1 w.	891402-25
R-90	48227	Resistor—304 ohms, 1 w.	891402-26
R-91	48228	Resistor—523 ohms, 1 w.	891402-27
R-92	48229	Resistor—1150 ohms, 1 w.	891402-28
R-93	48230	Resistor—4440 ohms, 1 w.	891402-29
R-101, 102	48234	Resistor—180 ohms, 1 w.	82284-141
R-103	43006	Resistor—270 ohms, 1 w.	82284-145

Symbol No.	Stock No.	Description	Dwg. No.
		LOWER CONTROL PANEL 613737-501—Continued	
R-104	38883	Resistor—330 ohms, 1 w.	82284-147
R-105	Same as R-101		
R-106	Same as R-103		
R-107	48811	Resistor—390 ohms, 1 w.	82284-149
R-108	38877	Resistor—1000 ohms, 1 w.	82284-159
R-109, 110	Same as R-101		
R-111	Same as R-103		
R-114	Same as R-104		
S-9	46066	Switch—Focus 1	878461-1
S-14	48242	Switch—Magnif.	427473-1
	27990	Knob	717296-502

TOP CHASSIS ASSEMBLY 613728-501

Symbol No.	Stock No.	Description	Dwg. No.
C-17	48812	Capacitor—0.1 mfd., 500 v.	72043-540
C-18 to C-20	18416	Capacitor—1.0 mfd., 150 v.	72043-533
C-21	30847	Capacitor—.05 mfd., 300 v.	72043-502
C-22	30859	Capacitor—.025 mfd., 1000 v.	72043-532
C-25	48163	Capacitor—.01 mfd., 1200 v.	891363-1
C-32	64735	Capacitor—.005 mfd., 500 v.	72043-537
C-33	Same as C-17		
C-34	30860	Capacitor—0.5 mfd., 200 v.	72043-523
C-35	48165	Capacitor—.0015 mfd., 500 v.	72073-544
C-36	48812	Capacitor—0.1 mfd., 500 v.	72043-540
C-37	18416	Capacitor—1.0 mfd., 150 v.	72043-533
C-38, 39	Same as C-36		
C-40	48160	Capacitor—.001 mfd., 500 v.	72073-527
C-41	48166	Capacitor—.005 mfd., 500 v.	72074-513
C-42	Same as C-17		
C-43	48813	Capacitor—.004 mfd., 1200 v.	891363-4
K-2	48814	Relay—Overload	427441-502
L-8	48815	Coil—Osc.	426612-501
L-9	28017	Coil—Choke	900526-502
L-10	48178	Coil—Choke	890305-1
R-15	30735	Resistor—560 ohms, 1 w.	78728-59
R-17	48187	Resistor—200 ohms, 10 w.	878435-12
R-18	Same as R-15		
R-28	33554	Resistor—820,000 ohms, 1 w.	78728-97
R-29	48194	Resistor—4 ohms, 1 w.	891402-2
R-30	5164	Resistor—560 ohms, ½ w.	78727-59
R-31	48195	Resistor—2500 ohms, 50 w.	427230-6
R-32	48196	Resistor—500 ohms, 25 w.	427230-3
R-33	14583	Resistor—220,000 ohms, ½ w.	78727-90
R-34	48186	Resistor—100 ohms, 10 w.	427230-1
R-35	32726	Resistor—560,000 ohms, 1 w.	78728-95
R-36	48198	Resistor—5000 ohms, 10 w.	878435-4
R-37	48771	Resistor—1 meg., 1 w.	891029-5
R-38	32723	Resistor—10 ohms, 1 w.	78728-38
R-39	31215	Resistor—100 ohms, 1 w.	78728-50
R-40	48194	Resistor—4 ohms, 1 w.	891402-2
R-41	48201	Resistor—500 ohms, 10 w.	878435-3
R-42	44364	Resistor—820,000 ohms, 2 w.	78724-97
R-46	48816	Resistor—10,000 ohms, 1 w.	878435-19
R-47	48204	Resistor—18,000 ohms, 10 w.	878435-5
R-48	30651	Resistor—270,000 ohms, ½ w.	78727-91
R-49	30409	Resistor—27,000 ohms, ½ w.	78727-79
R-50	30151	Resistor—18,000 ohms, 1 w.	78728-77
R-51	3252	Resistor—100,000 ohms, ½ w.	78727-86
R-52	48205	Resistor—6.5 meg., 2 w.	878432-2
R-53	44364	Resistor—820,000 ohms, 2 w.	78724-97
R-54	3058	Resistor—100,000 ohms, 1 w.	78728-86
R-55	13097	Resistor—10,000 ohms, 1 w.	78728-74
R-56	30149	Resistor—8200 ohms, 1 w.	78728-73
R-58	33554	Resistor—820,000 ohms, 1 w.	78728-97
R-59	30149	Resistor—8200 ohms, 1 w.	78728-73
R-60	14583	Resistor—220,000 ohms, ½ w.	78727-90

TOP CHASSIS ASSEMBLY 613728-501—Continued

Symbol No.	Stock No.	Description	Dwg. No.
R-67	13097	Resistor—10,000 ohms, 1 w.	78728-74
R-68	48194	Resistor—4 ohms, 1 w.	891402-2
R-69	48817	Resistor—35,000 ohms, 10 w.	878435-14
R-94	61028	Resistor—100 ohms, ½ w.	82283-50
R-95	48232	Resistor—10,000 ohms, 75 w.	427230-9
R-96	30735	Resistor—560 ohms, 1 w.	78728-59
R-97	Same as R-94		
R-98	Same as R-96		
R-99	Same as R-94		
R-117	30736	Resistor—22,000 ohms, 1 w.	78728-78
R-118	48196	Resistor—500 ohms, 25 w.	427230-3
T-4	48245	Transformer	901389-501
T-7	46033	Transformer	878736-1
T-8	64306	Transformer	878739-1
X-3	48250	Socket—Tube	878367-2
X-27	18007	Socket—Tube	844041-503
X-28	19458	Socket—Tube	844933-3
X-29	18007	Socket—Tube	844041-503
X-30	19395	Socket—Tube	844933-2
X-31	19458	Socket—Tube	844933-3
X-32	Same as X-31		
X-33	Same as X-30		
X-34	Same as X-29		
X-35, 36, 37	Same as X-34		
X-38	Same as X-30		
X-39	48253	Socket—Cable W-3	891473-1
X-53	48257	Socket—Cable W-12	891495-3
	69693	Insulator—R-52	426765-1
	69480	Insulator—R-37	426766-1

BOTTOM CHASSIS ASSEMBLY 302945-501

Symbol No.	Stock No.	Description	Dwg. No.
A-5	48818	Lamp—115 volts, 1 w.	849546-9
C-1	48159	Capacitor—1500 volts, 1 mfd.	878373-1
C-2	Same as C-1		
C-3	48158	Capacitor—1 mfd., 2000 v.	878374-1
C-4 to C-11	48159	Capacitor—125 mfd., 350 v.	86060-6
C-12	48160	Capacitor—.001 mfd., 500 v.	72073-527
C-13	48812	Capacitor—0.1 mfd., 500 v.	72043-540
C-14	48161	Capacitor—1.0 mfd., 600 v.	890311-1
C-16	18416	Capacitor—1.0 mfd., 150 v.	72043-533
F-1	48819	Fuse—15 amps.	99043-4
F-2	Same as F-1		
F-7	10907	Fuse	55544-4
K-1	48176	Relay—Vac. interlock	430529-1
L-1, 2	46045	Coil—Choke	878371-1
L-3	46044	Coil—Choke	878375-2
L-4, 5	46340	Coil—Choke	878375-1
R-1	48820	Resistor—0.8 ohm, 10 w.	878435-15
R-2	48180	Resistor—50,000 ohms, 1 w.	891402-8
R-3	48181	Resistor—80,000 ohms, 1 w.	891402-10
R-4	14583	Resistor—220,000 ohms, ½ w.	78727-90
R-5	32727	Resistor—680,000 ohms, 1 w.	78728-96
R-6, 7	5164	Resistor—560 ohms, ½ w.	78727-59
R-8	48182	Resistor—75,000 ohms, 1 w.	891402-9
R-9	34767	Resistor—2200 ohms, ½ w.	78727-66
R-10	48183	Resistor—660,000 ohms, 4 w.	878437-1
R-14	48186	Resistor—100 ohms, 10 w.	427230-1
R-16	2546	Resistor—1 meg., 1 w.	78728-98
R-20	48189	Resistor—50,000 ohms, 50 w.	427230-35
R-62	48181	Resistor—80,000 ohms, 1 w.	891402-10
R-112	43609	Rheostat—10 ohms, 100 w.	849811-1
R-113	48821	Resistor—5 ohms, 50 w.	427491-1
R-115, 116	18190	Resistor—47 ohms, 1 w.	78728-46
T-1	48243	Transformer	891390-1
T-2	48244	Transformer	878376-1
T-3	46036	Transformer	878377-1

BOTTOM CHASSIS ASSEMBLY 302945-501—Continued

Symbol No.	Stock No.	Description	Dwg. No.
T-5	48246	Transformer	878372-1
T-6	17692	Transformer	900168-502
T-9	48247	Transformer	878735-1
X-8	23540	Receptacle—Pilot lamp	99014-1
X-9, 10	23540	Receptacle—Fuse	99014-1
X-12	18007	Socket—Tube	844041-503
X-13	Same as X-12		
X-14	18007	Receptacle—Cable W-5	844041-503
X-16, 17	19548	Socket—Tube	844933-3
X-18 to X-23	Same as X-12		
X-24	48251	Receptacle—Cable W-6	878746-1
X-25	Same as X-12		
X-26	48252	Receptacle—Cable W-4	878746-2
X-57 to X-64	45368	Socket—Capacitor	181516-2
X-74	45851	Fuse Holder—Cartridge	844027-2
	69693	Insulator—Porcelain for R-10 and plate leads	426765-1

H. V. UNIT ASSEMBLY 302951-501

Symbol No.	Stock No.	Description	Dwg. No.
C-23	47932	Capacitor—.02 mfd., 600 v.	891363-2
C-24	47933	Capacitor—.006 mfd., 600 v.	891363-3
C-26, C-27, C-28	47934	Capacitor—.0005 mfd.	504400-501
C-29	47935	Capacitor—.025 mfd., 50,000 v.	718572-1
C-30	Same as C-26		
C-31	47936	Capacitor—1.0 mfd., 400 v.	72049-538
C-44	47937	Capacitor—.000025 mfd.	504425-501
L-13 includes			
T-13	47938	Coil—Tank coil and fil. trans. assem.	427255-501
L-15	48468	Coil—Ripple trap	427456-501
LR-1	47939	Lightning Arrester	878473-1
R-65	47940	Resistor—1000 meg.	869085-1
T-12	47941	Coil—Filament transformer	427256-501
T-13	47938	Part of L-13 and T-13 assem.	
V-28, V-29, V-30	42715	Tube—8013-A	
X-48, X-49, X50	47942	Socket—8013-A tube	878546-1
X-51	48256	Connector—3 contact	891136-1

HIGH VOLTAGE BUSHING 613583-501

Symbol No.	Stock No.	Description	Dwg. No.
R-43	48202	Resistor—200,000 ohms, 6 w.	859882-1
R-44	48203	Resistor—47 ohms, ½ w.	850981-46
R-45	48203	Same as R-44	
Part of T-10	47351	Coil—Outer coil assem.	718956-501
Part of T-10	48035	Coil—Inner coil assem.	430518-501
X-73	48261	Connector—3 contact, male	891494-1

ELECTRON GUN 613795-501—427244-501

Symbol No.	Stock No.	Description	Dwg. No.
	48799	Aperture—Electron gun	859376-1
	48113	Bellows—Electron gun or internal bellows	859962-3
	48100	Bushing—Insulating filament mtg. plate	802332-1
	48103	Coupling—Worm gear	891027-1
	44511	Filament Assembly—Radiotron FM-2379 (V-31)	
	48140	Gasket—Glass shield bottom	613792-61
	48139	Gasket—Glass shield top	613792-60
	48141	Gasket—Gun assembly bottom	613792-65

ELECTRON GUN 613795-501—427244-501—Continued

Symbol No.	Stock No.	Description	Dwg. No.
	48803	Gasket—Internal bellows	613792-58
	48142	Gasket—Window	613792-62
	48102	Gear Assembly—Filament adjusting	859371-501
	48109	Internal Bellows Assembly Complete	878517-501
	48107	Knob Assembly—Gun lateral adjusting	890300-501
	48105	Plug—Adjusting shaft spring	890306-1
	48111	Screen—Window	859388-1
	48106	Screw—Lateral adjusting	891498-1
	65977	Screw—#4-40 x ⅛″ Allen set screw for electron gun filament assembly	843365-41
	44732	Screw—#8-32 x ⅛″ Allen set screw for worm gear coupling	843365-11
	48804	Screw—#10-32 x ⅝″ socket head screw for electron gun	881919-13
	48101	Seal—Vacuum electron gun	859370-501
	48104	Shaft—Lateral adj. self-regulating	878499-1
	48108	Shield—Glass shield less top and bottom plates	859392-1
	48800	Sleeve—Cathode sleeve	427245-1
	48801	Spring—Internal bellows	427496-1
	48802	Spring—Lateral adjustment shaft	718955-3
	48110	Window—Electron gun	859387-1
	48112	Worm Drive Assembly	415344-7

SPECIMEN CHAMBER ASSEMBLY 718946-501

Symbol No.	Stock No.	Description	Dwg. No.
	48406	Cam Assembly—Door knob shaft and cam	891186-501
	48483	Cap—Specimen holder cap	892010-1
	48378	Gasket—Specimen chamber bottom	613792-71
	48384	Gasket—Specimen chamber-door	613792-86
	48408	Gasket—Door knob shaft	613792-85
	48374	Gear—Micrometer gear	891164-1
	48405	Knob—Specimen chamber door	891176-1
	48387	Lifter Assembly—Specimen lifter	878580-501
	47985	Packing—Door knob shaft and micrometer screw	878391-1
	48806	Pin—Knob travel limit	891181-1
	47628	Screen—Specimen screen	891152-1
	48377	Screw—Micrometer screw	891166-1
	48376	Shaft—Worm gear	891177-1
	48404	Specimen Holder Assembly (Stereo)	891194-501
	48390	Specimen Holder Assembly (Standard)	891193-501
	48407	Spring—Door knob shaft	718955-18
	48805	Spring—Knob limit pin	718955-10
	48379	Spring—Micrometer gear—L.H.	890320-1
	48380	Spring—Micrometer gear—R.H.	890320-2
	48386	Spring—Micrometer screw	718995-13
	48385	Spring—Hold down spring	890334-1
	48381	Spring Assembly—With 2 anvils	878726-501
	48382	Spring Assembly—With 2 anvils (1 slotted)	878726-502
	48383	Spring Assembly—With 1 anvil	878726-503
	48375	Worm—Micrometer gear	891164-2

DIFFRACTION UNIT 613750-501

Symbol No.	Stock No.	Description	Dwg. No.
X-42	48255	Plug—Male	878440-1
	48807	Gasket—Bottom	613792-66
	47127	Gasket—Window	613792-41
	47129	Window	870447-1

STAGE ASSEMBLY 718680-501

Symbol No.	Stock No.	Description	Dwg. No.
	47149	Aperture—Reflection	870440-2
	47116	Ball—Axial adj. rod	76757-18
	48032	Bushing—Packing pressure	878536-1
	47108	Cap—Specimen holder	426145-3
	48225	Connector—Coil male	878440-1
	47110	Gasket—Pushrod	613792-43
	48027	Gasket—Stage	613792-73
	48031	Hand Wheel—Less handles	878719-1
	47115	Handle—For handwheel	878533-1
	46999	Packing—Push rods	878391-2
	47105	Pin—Swivel pin—Tilting pushrod	878535-1
	47103	Push Rod Assembly—Rot. and axial adj.	870430-502
	47102	Push Rod Assembly—Tilting	870430-501
	48028	Ring—Gasket thrust ring	870411-3
	46603	Screen—Specimen	858753-1
	47117	Shaft—Axial adj.	870432-3
	47106	Specimen Holder—Reflection	878527-1
	47107	Specimen Holder—Transmission	870440-1
	46998	Spring—Conical—Tilting push rod	878534-1
	46997	Spring—Helical—Push rod packing	718955-9
	47113	Thumbwheel—Angular adj.	878740-1
	47111	Thumbwheel—Spec. rotation	870429-1
	47112	Thumbwheel—Transverse adj.	878741-1

VIEWING CHAMBER ASSEMBLY 613725-501

Symbol No.	Stock No.	Description	Dwg. No.
V-13	48249	Ionization Gauge	427437-1
	48021	Bracket—Rack	891123-1
	48013	Cable Release	878492-1
	47735	Gasket—(Bottom)	613792-57
	47733	Gasket—(Ionization gauge)	613792-54
	48009	Gasket—Pinion sleeve	613792-84
	47745	Gasket (Window)	613792-79
	48007	Gear Assembly—For screen	878477-501
	48014	Magnet—Ionization gauge	427438-1
	47985	Packing—Viewing screen shaft	878391-1
	48008	Rack—Screen moving	878479-1
	48656	Screen—Ionization gauge	859388-3
	48005	Screen—Viewing complete	427228-501
	48015	Spring—Pinion	891471-1
	48010	Spring—Pinion shaft packing	718955-13
	48006	Window—Viewing chamber	878320-1

PHOTO CHAMBER ASSEMBLY 613717-501

Symbol No.	Stock No.	Description	Dwg. No.
	47986	Bearing—Roller bearing—Pinion shaft	855201-4
	47995	Gasket—Door	613792-80
	47981	Gasket—Knob	613792-67
	47989	Handle—Photo chamber door	878314-1
		B-1 Taper Pin	59127-21
	47991	Hinge—Photo chamber door	878319-1
		B-1 Pin	878335-2
	47987	Gear—Photo chamber	878399-1
	17268	Knob Assem.—Photo chamber	712336-505
	47990	Latch—Photo chamber door latch	878315-1
			878335-1
	47985	Packing—Knob shaft	878391-1
	47994	Pin—Cassette stop pin	878568-1
	47993	Rack—Carriage—Photo chamber	878381-1
	47992	Screw—Stop screw—Photo chamber door	878318-1
	47984	Shaft—Knob	878401-1
	48808	Shaft—Pinion	878402-1
	47983	Spring—Packing pressure	718955-12
	47982	Spring—Cassette stop pin	718955-26

VALVING MECHANISM

Symbol No.	Stock No.	Description	Dwg. No.
		VALVE DRIVE	
	47928	Bushing and Bearing Assembly	891397-1
			855201-1
	47927	Crank Assembly	878455-501
			891248-1
			891405-1
			82278-55
			59048-60
	47930	Joint—Universal	891398-2
			833365-11
	47929	Spring—Valve drive	878457-1
S-6	43177	Switch—Micro switch	844593-1
	47720	Arm Assem.—"D" valve	878420-501
	47721	Arm Assem.—Indent wheel	878420-502
	47731	Bearings—Roller bearing—3/8" I.D. x 9/16" O.D.	855201-6
	47732	Bearings—Roller bearing—3/16" I.D. x 11/32" O.D.	855201-7
	47730	Bearings—Roller bearing—5/16" I.D. x 1/2" O.D.	855201-5
	47713	Bellows—Metallic bellows for "A" and "B" valve	859962-12
	47705	Bellows—Metallic bellows for "C" valve	859962-13
	47725	Cam—"A" valve	718673-3
	47726	Cam—"B" valve	718673-4
	47723	Cam—"C" valve	718673-1
	47724	Cam—"D" valve	718673-2
	47718	Coupling—(for flex. shaft)	891295-1
	48736	Gasket—"D" valve shaft	613792-51
	47716	Gasket—"A" and "B" valve (inner)	613792-53
	47733	Gasket—"A" and "B" valve (outer) and air tubes	613792-54
	47708	Gasket—for "C" valve (inner)	613792-52
	47734	Gasket—for "C" valve (outer)	613792-55
	47735	Gasket—(to column and oil diff. pump)	613792-57
	47729	Gear—Large	878397-2
	47728	Gear—Small	878397-1
	47930	Joint—Universal joint	891398-2
	47736	Nipple—Hose	891399-1
	47738	Shaft—"A" and "B" cams	878424-2
	47710	Shaft—"A" and "B" valve	891388-1
	47702	Shaft—"C" valve	878396-1
	47737	Shaft—"C" and "D" and indent cams	878424-1
	47739	Shaft—Drive	878424-3
	47740	Spring—Indent arm	878457-2
	47727	Tubing Assem. (air lines)	878433-501
	47709	Valve Assembly—"A" and "B" valve	878411-501
	47714	Spring—for "A" and "B" valve	718955-15
	47711	Valve Bushing for "A" and "B"	878406-1
	47715	Valve end for "A" and "B" valve	878393-1
	47712	Valve Plate—"A" and "B" valve	878404-1
	47701	Valve Assem.—"C" valve	878410-501
	47706	Spring—for "C" valve	718955-14
	47703	Valve bushing for "C" valve	878405-1
	47707	Valve End—for "C" valve	878394-1
	47704	Valve Plate—for "C" valve	878404-2
	47717	Valve Disc Assem.—"D" vale	858486-501
	47741	Spring—"D" valve	718955-16
	47722	Wheel—Detent wheel	878450-1
	47719	Yoke—"D" valve	878413-1

VACUUM PUMP 718951-1

Symbol No.	Stock No.	Description	Dwg. No.
	48843	Belt—Motor drive belt	Pt. of 718951-1
	48844	Motor—50 cycle—115 volt-230 volt	Pt. of 718951-2
	48842	Motor—60 cycle—115 volt-230 volt	Pt. of 718951-1
	48845	Oil—Vacuum pump oil	890324-1
	48841	Pump—Vacuum pump only (A-7) (less motor, pulley and belt)	Pt. of 718951-1

BATTERY BOX (For Cabinet) 613719-501

Symbol No.	Stock No.	Description	Dwg. No.
B-1 to B-8	47213	Battery—45 volts	891434-1
B-9	47215	Battery—22½ volts	891435-1
B-10	47213	Battery—45 volts	891434-1
B-11	47214	Battery—22½ volts	891455-1
F-4, 5, 6	3748	Fuse—½ amp.	55544-11
J-1	47943	Plug—Battery box	878438-1
J-3 to J-10	47943	Plug—Battery box	878438-1
X-44 to X-46	45851	Fuse Holder	844027-2

OIL DIFFUSION PUMP 613786-501

Symbol No.	Stock No.	Description	Dwg. No.
S-15	47698	Thermoswitch	891105-1
X-67	47700	Plug	891106-1
	47699	Coupling	891104-1

CABLES AND CONNECTORS

Symbol No.	Stock No.	Description	Dwg. No.
W-1	48822	Cable—Control panel to coils	427476-501
J-11-12	48168	Connector—Female for Cable W-1	878362-1
J-13	48836	Connector—Female for Cable W-1	878364-1
J-14	35383	Connector—Male for Cable W-1	413691-8
W-2	48823	Cable—Top chassis to battery box	427257-501
J-24	48838	Connector—Male for Cable W-2	890396-1
W-3	48824	Cable—Control panel to top chassis	427477-501
J-17-30	48169	Connector—Female for Cable W-3	891472-1
W-4	48825	Cable—Top chassis to bottom chassis	427478-501
J-20	48170	Connector—Female for Cable W-4	878745-2
W-5	48826	Cable—Column to bottom chassis	427479-501
J-19	35383	Connector—Male for Cable W-5	413691-8
W-6	48827	Cable—Control panel to bottom chassis	427480-501
J-16	35383	Connector—Male for Cable W-6	413691-8
J-18	48837	Connector—Female for Cable W-6	878745-1
J-2	48167	Connector—Female for Cable W-6	878745-3
W-7	48828	Cable—Thermocouple to bottom chassis	427481-501
J-15	35354	Connector—Female for Cable W-7	413691-9
J-25	35383	Connector—Male for Cable W-7	413691-8
W-8	48829	Cable—Bottom chassis to diffusion pump	427482-501
J-26	48174	Connector—Female for Cable W-8	890317-1
W-9	48830	Cable—High voltage unit to top chassis	427497-501
J-29	48839	Connector—Female for Cable W-9	891475-1
W-10	48831	Cable—High voltage unit to top chassis	427484-501
W-11	48832	Cable—High voltage unit to top chassis	427485-501
J-22	48172	Connector—Male for Cable W-11	878750-1
W-12	48833	Cable—Top chassis to high voltage bushing	427486-501
J-21	48171	Connector—Male for Cable W-12	891495-2
J-27	48175	Connector—Female for Cable W-12	891495-1
W-13	48834	Cable—Interlock	427489-501
W-14	48835	Cable—Interlock	427488-501
J-23	48173	Connector—Female—Connects into X-51	891135-1

MISCELLANEOUS MATERIAL AND PARTS

Symbol No.	Stock No.	Description	Dwg. No.
	47925	Box—Utility box	891425-1
	48388	Centering Pin—For stage	891350-1
	47656	Coating—Fluorescent 1 oz. (powder)	
	46605	Film Making Kit—Complete	
	48287	Grease—Cello grease	890322-1
	48030	Grease—Lubrico grease	891458-1
	47924	Lifter—Pole piece	718950-501
	48387	Lifter—Spec. holder	878580-501
	45924	Oil—Diffusion pump	
	47923	Rod—Filament adjusting	891028-501
	47790	Tongs—Internal manifold	427266-501
	44218	Tongs—Pole piece	426501-1
	46698	Wax—Picein or apiezon wax	890321-1
	46699	Allen Wrench—#4 screw	828505-14
	19996	Allen Wrench—#6 screw	828505-13
	14991	Allen Wrench—#8 screw	828505-12
	26581	Allen Wrench—#10 screw	828505-1
	22112	Allen Wrench—¼" screw	828505-2
	22113	Allen Wrench—5⁄16" screw	828505-3
	22111	Allen Wrench—⅜" screw	828505-4
	62967	Allen Wrench—5⁄16" cap screw	828505-5
	64199	Allen Wrench—⅜" cap screw	828505-7
	48389	Wrench—Cassette control nut	891409-1
	47926	Wrench—Spanner	718950-6

RCA MANUFACTURING CO., INC., CAMDEN., N.J.

CALCULATION AND TEST SHEET M-427495

EQUIPMENT ELECTRON MICROSCOPE TYPE "EMU-I"
EQUIPMENT NO. MI-12957
ASSEM. & D.L. K-891303

SCHEMATIC W-302952
ENGINEER S.M.ZOLLERS
DATE JAN. 20,1944

D.C.SUPPLY 1240 VOLTS 680 VOLTS 410 VOLTS
88 M.A. 115 M.A. 150 M.A.
HIGH VOLTAGE SUPPLY 50,000 VOLTS .5 M.A.
A.C.SUPPLY-115 VOLTS-1000 WATTS

				VOLTS						AMPS				PLATE RESISTOR		FILTER RESISTOR		SCREEN RESISTOR		CATHODE RESISTOR				
TUBE NO.	TUBE TYPE	FUNCTION	OPER. CONDITION	E PLATE	E SCREEN	E CATH.	E GRID	E HEATER	E FILTER	I PLATE	I SCREEN	I CATH.	I HEATER	OHMS	WATTS	OHMS	WATTS	OHMS	WATTS	OHMS	WATTS	PLATE WATTS	SCREEN WATTS	TUBE NO.
V-1	1616	RECTIFIER	MAX.BEAM	1180AC	—	1240	—	2.5	—	.088	—	.088	5	—	—	—	—	—	—	—	—	110	—	V-1
V-2	1616	RECTIFIER	MAX.BEAM	1180AC	—	1240	—	2.5	—	.088	—	.088	5	—	—	—	—	—	—	—	—	110	—	V-2
V-3	5R4GY	RECTIFIER	NORMAL	500AC	—	690	—	5	—	.115	—	.115	2	—	—	—	—	—	—	—	—	80	—	V-3
V-4	5R4GY	RECTIFIER	NORMAL	500AC	—	470	—	5	—	.150	—	.150	2	—	—	—	—	—	—	—	—	70	—	V-4
V-5	VR-150	VOLT. REG.	NORMAL	152	—	0	—	—	—	.006	—	.006	—	—	—	—	—	—	—	—	—	.9	—	V-5
V-6	6SF5	D.C. AMP.	NORMAL	350	—	151.5	150	6.3	—	.00045	—	.00045	0.3	680,000	.13	—	—	—	—	—	—	.16	—	V-6
V-7	6L6	SERIES REG.	NORMAL	700	700	390	350	6.3	—	.057	.005	.062	.9	—	—	—	—	560	.002	—	—	17.5	1.5	V-7
V-8	6L6	SERIES REG.	NORMAL	700	700	390	350	6.3	—	.057	.005	.062	.9	—	—	—	—	560	.002	—	—	17.5	1.5	V-8
V-9	991	INDICATOR	MAXIMUM CURRENT	160	—	100	—	—	—	.002	—	.002	—	—	—	—	—	—	—	—	—	.12	—	V-9
V-10	6H6	RECTIFIER	MAXIMUM CURRENT	220	—	200	—	6.3	—	.0002	—	.0002	0.3	1 MEG.	.04	—	—	—	—	—	—	.004	—	V-10
V-11	6L6	AMPLIFIER	NORMAL	60	70	0	-5	6.3	—	.008	.004	.012	0.9	—	—	—	—	—	—	—	—	.47	.27	V-11
V-12	THERMOCOUPLE GAGE		NORMAL	—	—	—	—	.4	—	—	—	—	.085	—	—	—	—	—	—	—	—	—	—	V-12
V-13	ION. GAGE		MAXIMUM CURRENT	2150AC	—	100	—	—	—	.001	—	.001	—	660,000	.66	—	—	—	—	—	—	—	—	V-13
X-27 V-14	6Y6-G	SERIES REG.	NORMAL	410	410	266	256	6.3	—	.085	.005	.090	1.25	—	—	—	—	560	.014	—	—	12	.7	V-14
V-15	811	SERIES REG.	MAX.BEAM	1240	—	700	730	6.3	—	.086	—	.106	4	—	—	—	—	—	—	—	—	46	—	V-15
X-29 V-16	12SJ7	D.C. AMP.	NORMAL	253	45	0	-2.75	12.6	—	.00016	.0001	.0003	0.15	820,000	.02	—	—	—	—	—	—	.05	.01	V-16
V-17	807	SERIES REG.	MAX.BEAM	1240	1000	730	700	6.3	—	.040	.005	.045	0.9	100	.15	—	—	560	.014	5000	.2	20	1.3	V-17
V-18	811	OSCILLATOR	MAX.BEAM	700	—	1	-34.0	6.3	—	.070	—	.100	4	10	.06	—	—	—	—	4	.1	50	—	V-18
V-19	811	OSCILLATOR	MAX.BEAM	700	—	1	-36.5	6.3	—	.090	—	.126	4	—	—	—	—	—	—	SEE V-18		63	—	V-19
V-20	807	D.C. AMP.	NORMAL	700	310	155	133	6.3	—	.001	.005	.006	0.9	560,000	.56	—	—	560	.014	—	—	.6	.78	V-20
V-21	VR-150	VOLT. REG.	NORMAL	155	—	0	—	—	—	.014	—	.014	—	—	—	—	—	—	—	—	—	2.1	—	V-21
V-22	12SJ7	D.C. AMP.	NORMAL	133	150	0	-7.4	12.6	—	.00095	.00032	.0013	0.15	270,000	.24	—	—	18,000	.16	—	—	.13	.05	V-22
V-23	6L6	SERIES REG.	NORMAL	390	365	154	145	6.3	—	.049	.003	.052	0.9	—	—	—	—	8200	.076	—	—	11.5	.63	V-23
V-24	12SJ7	D.C. AMP.	NORMAL	150	22	0	-2.9	12.6	—	.0003	.0001	.0004	0.15	820,000	.073	—	—	—	—	—	—	.05	.002	V-24
V-25	991	INDICATOR	MAXIMUM CURRENT	63	—	0	—	—	—	.0017	—	.0017	—	—	—	—	—	—	—	—	—	.1	—	V-25
V-26	991	METER PROTECTION	PEAK	94	—	0.5	—	—	—	.0005	—	.0005	—	—	—	—	—	—	—	—	—	.05	—	V-26
V-27	807	OSCILLATOR	MAX.BEAM	270	128	0	-40	6.3	—	.048	.0045	.0525	0.9	—	—	—	—	33,000	.65	4	.0015	8.1	.58	V-27
V-28	8013A	RECTIFIER	NORMAL	-16,700	—	54	—	2.5	—	.0007	—	.0007	5	—	—	—	—	—	—	—	—	11.7	—	V-28
V-29	8013A	RECTIFIER	NORMAL	-33,300	—	-16,700	—	2.5	—	.0007	—	.0007	5	—	—	—	—	—	—	—	—	11.7	—	V-29
V-30	8013A	RECTIFIER	NORMAL	-50,000	—	-33,300	—	2.5	—	.0007	—	.0007	5	—	—	—	—	—	—	—	—	11.7	—	V-30

NOTE:- ALL VOLTAGES MEASURED TO GROUND — EXCEPT HEATER VOLTAGES.

131
F11

SUB 2 MAY 26,1944 S.M. ZOLLERS

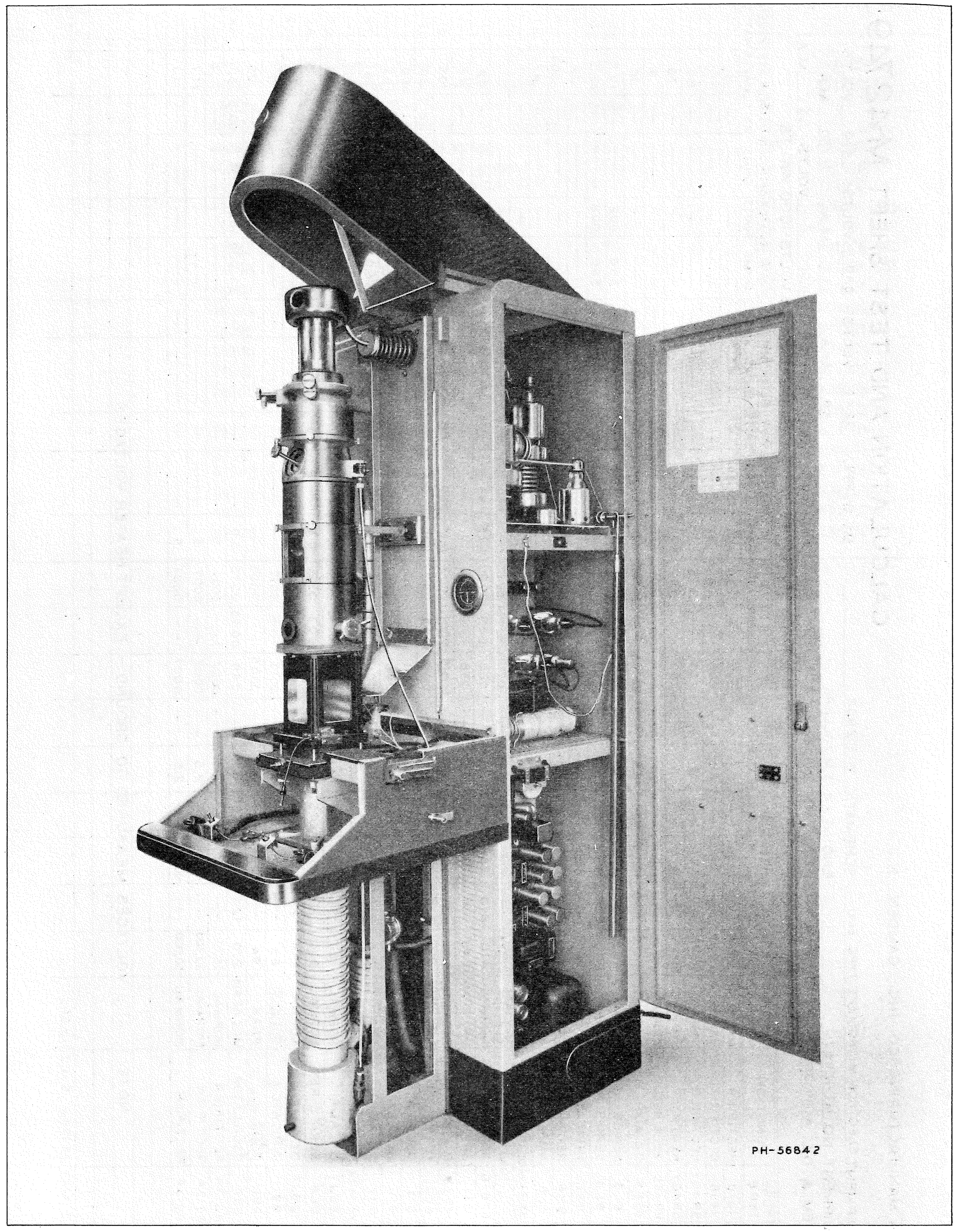


Figure 17—Electron Microscope Type EMU, Right Side View, Door and Hood Open, Column and Diffusion Pump Exposed, Control Panel Removed

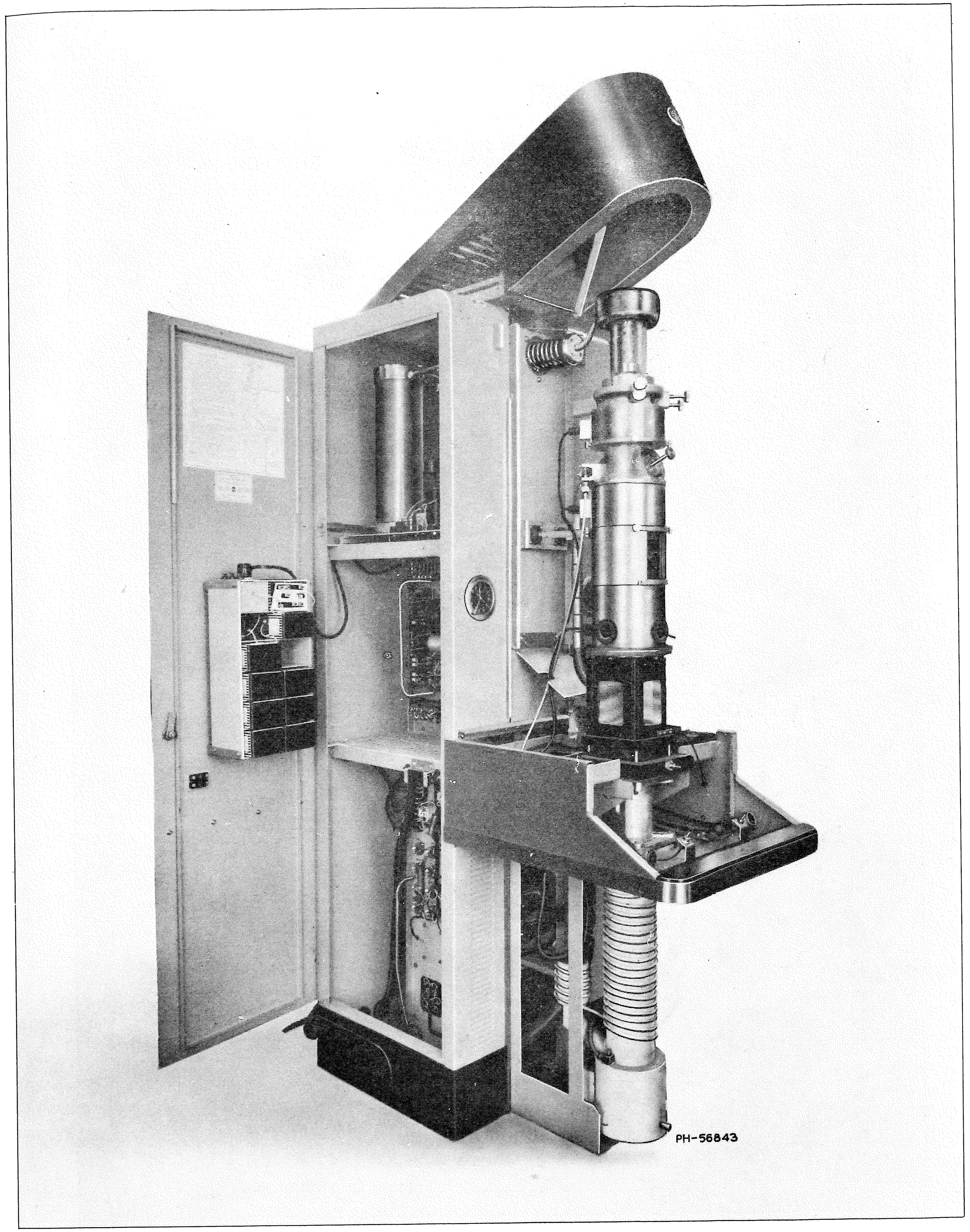


Figure 18—Electron Microscope Type EMU, Left Side View, Door and Hood Open, Column and Diffusion Pump Exposed, Control Panel Removed

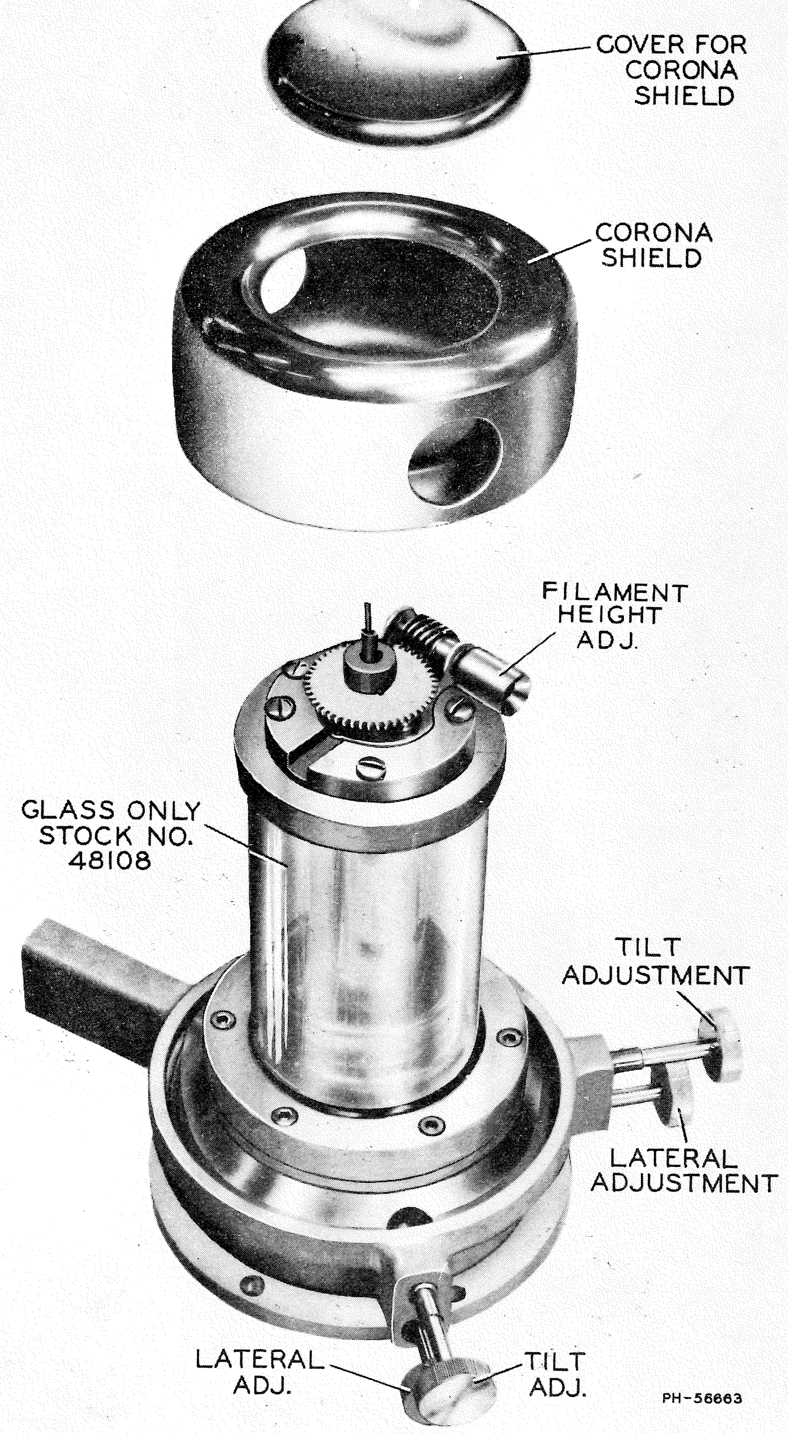

COVER FOR CORONA SHIELD
CORONA SHIELD
FILAMENT HEIGHT ADJ.
GLASS ONLY STOCK NO. 48108
TILT ADJUSTMENT
LATERAL ADJUSTMENT
LATERAL ADJ.
TILT ADJ.
PH-56663

Figure 19—*Electron Gun with Base and Corona Shields*

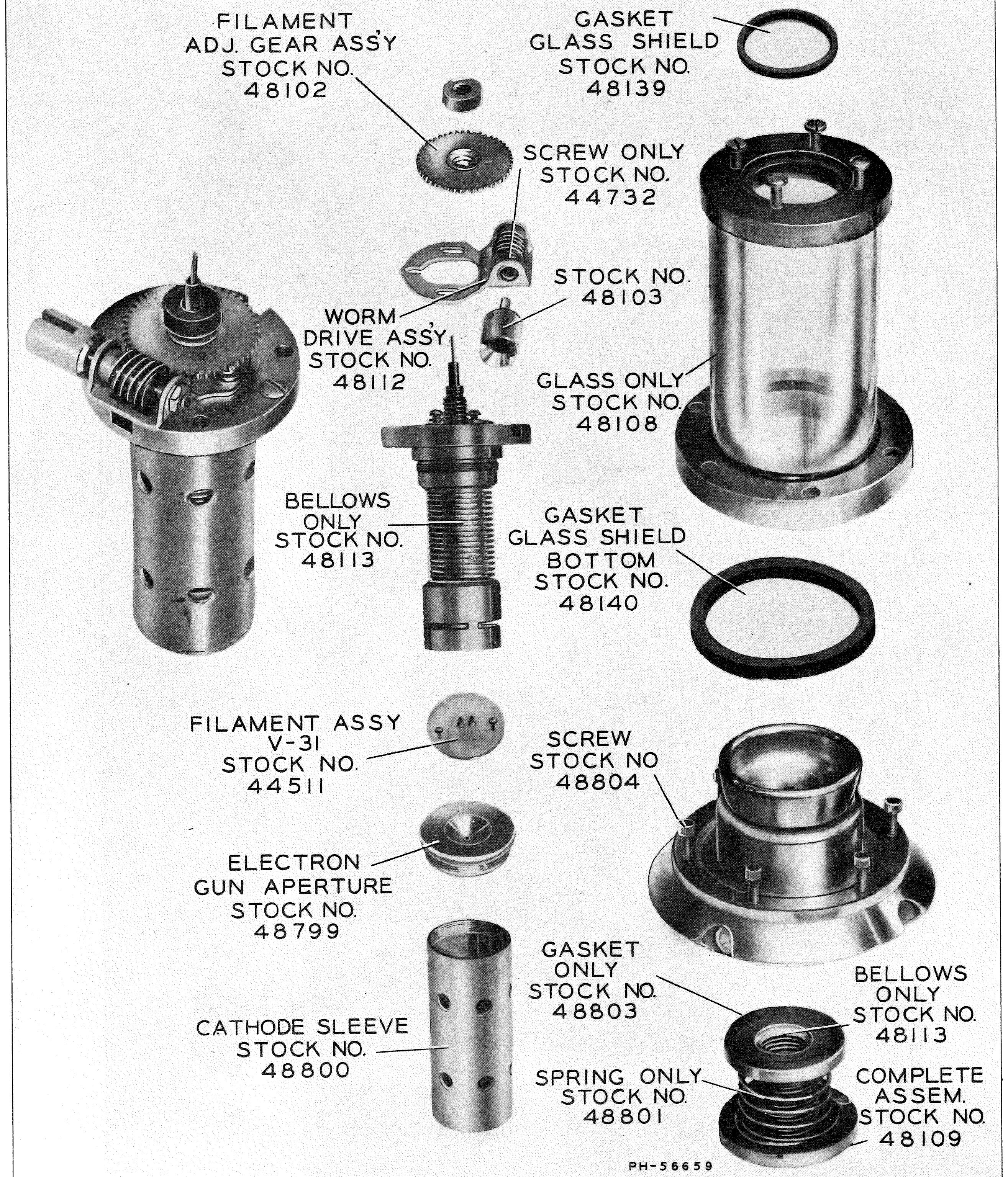

FILAMENT ADJ. GEAR ASS'Y STOCK NO. 48102
GASKET GLASS SHIELD STOCK NO. 48139
SCREW ONLY STOCK NO. 44732
STOCK NO. 48103
WORM DRIVE ASS'Y STOCK NO. 48112
GLASS ONLY STOCK NO. 48108
BELLOWS ONLY STOCK NO. 48113
GASKET GLASS SHIELD BOTTOM STOCK NO. 48140
FILAMENT ASSY V-31 STOCK NO. 44511
SCREW STOCK NO 48804
ELECTRON GUN APERTURE STOCK NO. 48799
GASKET ONLY STOCK NO. 48803
BELLOWS ONLY STOCK NO. 48113
CATHODE SLEEVE STOCK NO. 48800
SPRING ONLY STOCK NO. 48801
COMPLETE ASSEM. STOCK NO. 48109
PH-56659

Figure 20—*Electron Gun Assembly and Parts*

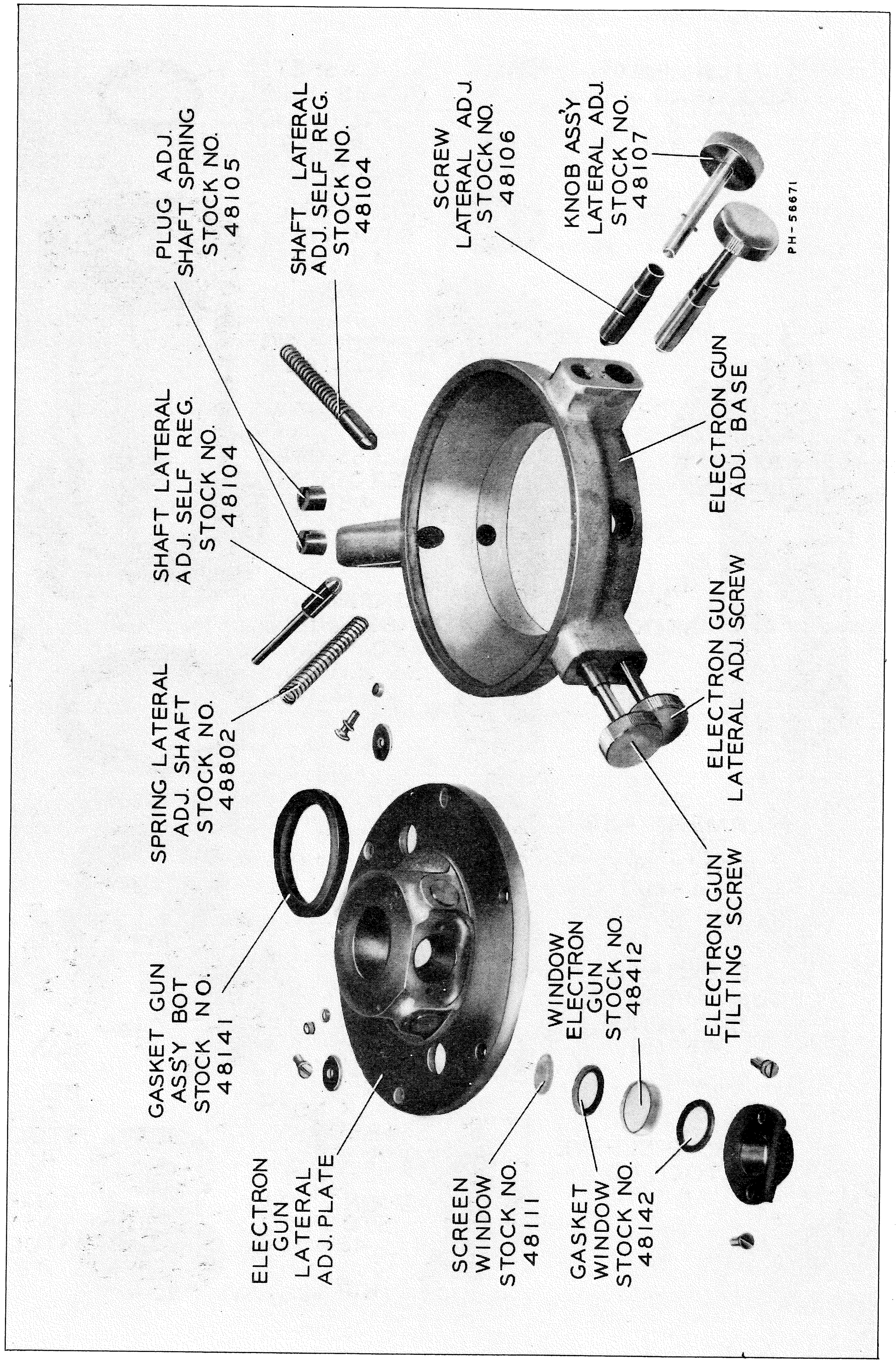

PLUG ADJ. SHAFT SPRING STOCK NO. 48105
SHAFT LATERAL ADJ. SELF REG. STOCK NO. 48104
SCREW LATERAL ADJ. STOCK NO. 48106
KNOB ASS'Y LATERAL ADJ. STOCK NO. 48107
PH-58671
SHAFT LATERAL ADJ. SELF REG. STOCK NO. 48104
ELECTRON GUN ADJ. BASE
SPRING LATERAL ADJ. SHAFT STOCK NO. 48802
ELECTRON GUN ADJ. SCREW
ELECTRON GUN LATERAL ADJ. SCREW
GASKET GUN ASS'Y BOT STOCK NO. 48141
WINDOW ELECTRON GUN STOCK NO. 48412
ELECTRON GUN TILTING SCREW
ELECTRON GUN LATERAL ADJ. PLATE
SCREEN WINDOW STOCK NO. 48111
GASKET WINDOW STOCK NO. 48142

Figure 21—Electron Gun Base Disassembled

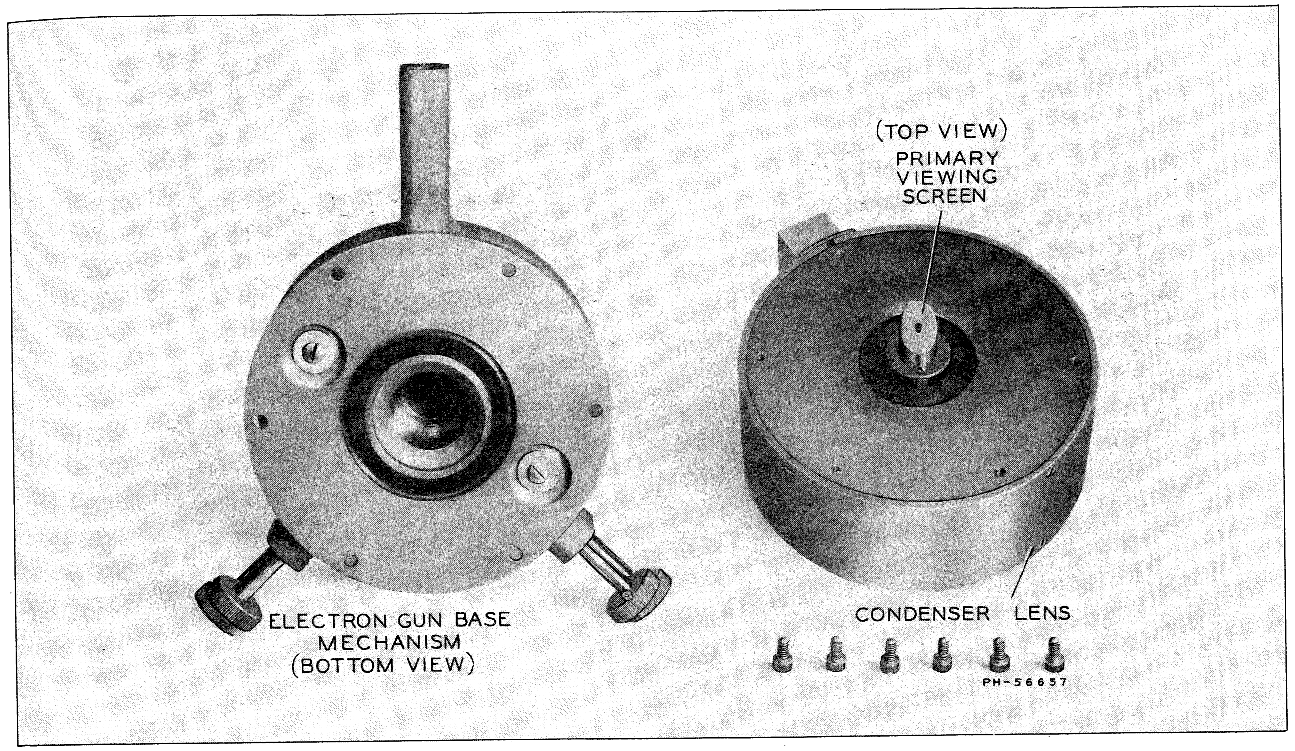

(TOP VIEW)
PRIMARY VIEWING SCREEN
ELECTRON GUN BASE MECHANISM (BOTTOM VIEW)
CONDENSER LENS
PH-56657

Figure 22—Electron Gun Base and Condenser Lens

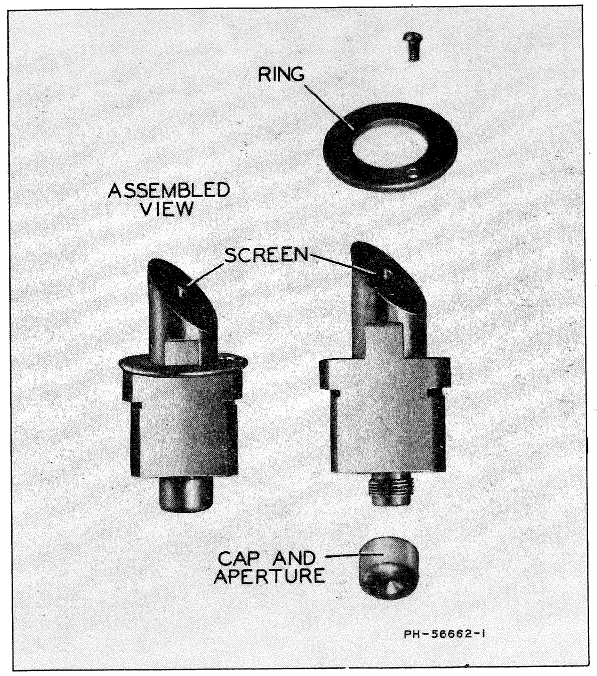

RING
ASSEMBLED VIEW
SCREEN
CAP AND APERTURE
PH-56662-1

Figure 23—Primary Viewing Screen and Condenser Aperture

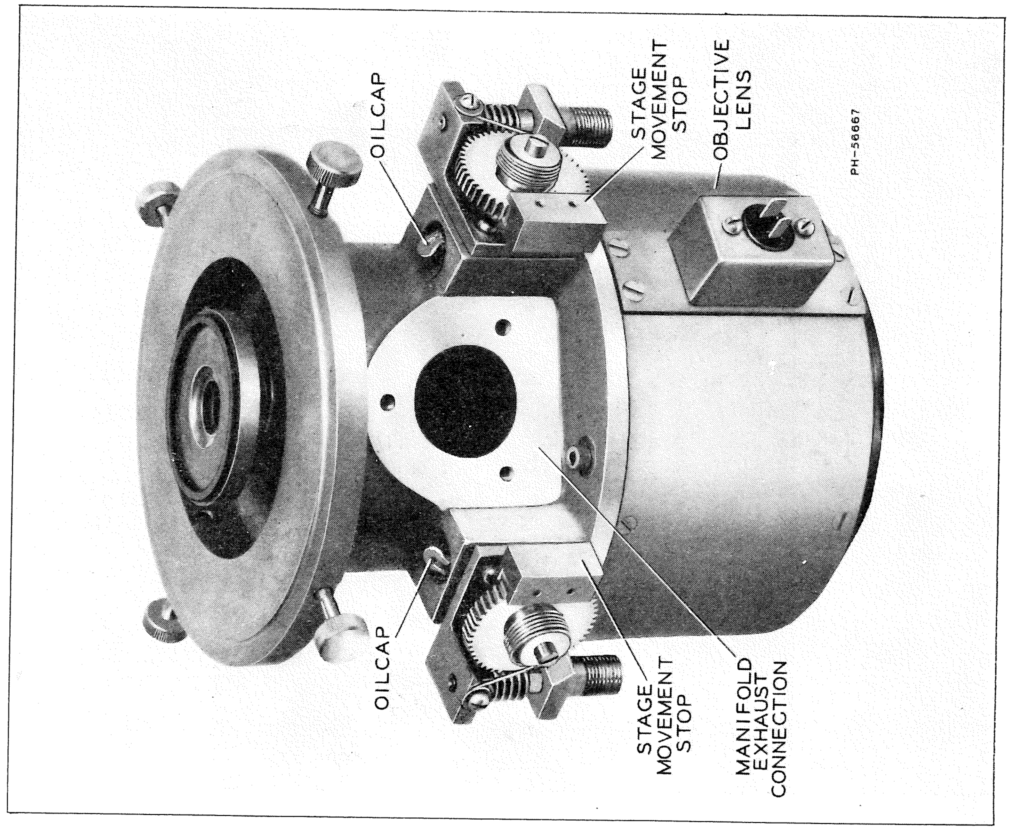

OILCAP
STAGE MOVEMENT STOP
OBJECTIVE LENS
PH-56667
OILCAP
STAGE MOVEMENT STOP
MANIFOLD EXHAUST CONNECTION

Figure 24—Specimen Chamber and Objective Lens, Rear View

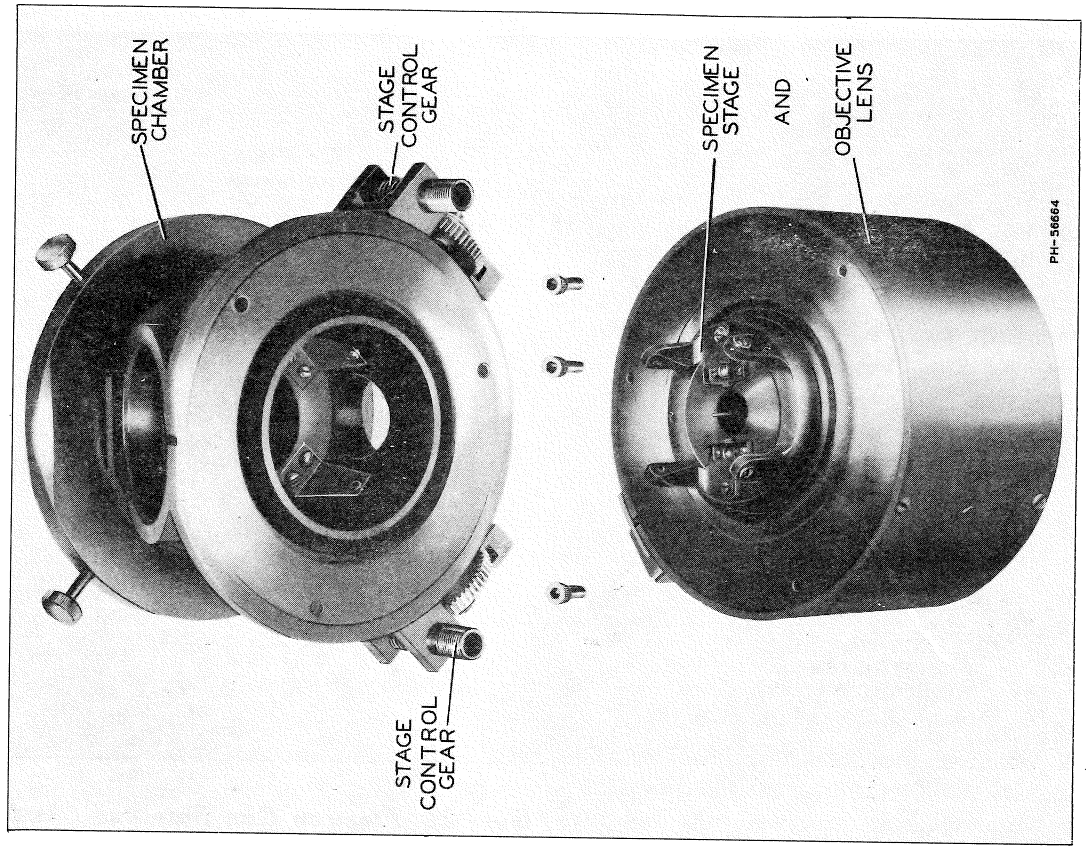

SPECIMEN CHAMBER
STAGE CONTROL GEAR
SPECIMEN STAGE AND OBJECTIVE LENS
PH-56664
STAGE CONTROL GEAR

Figure 25—Specimen Chamber, Specimen Stage and Objective Lens

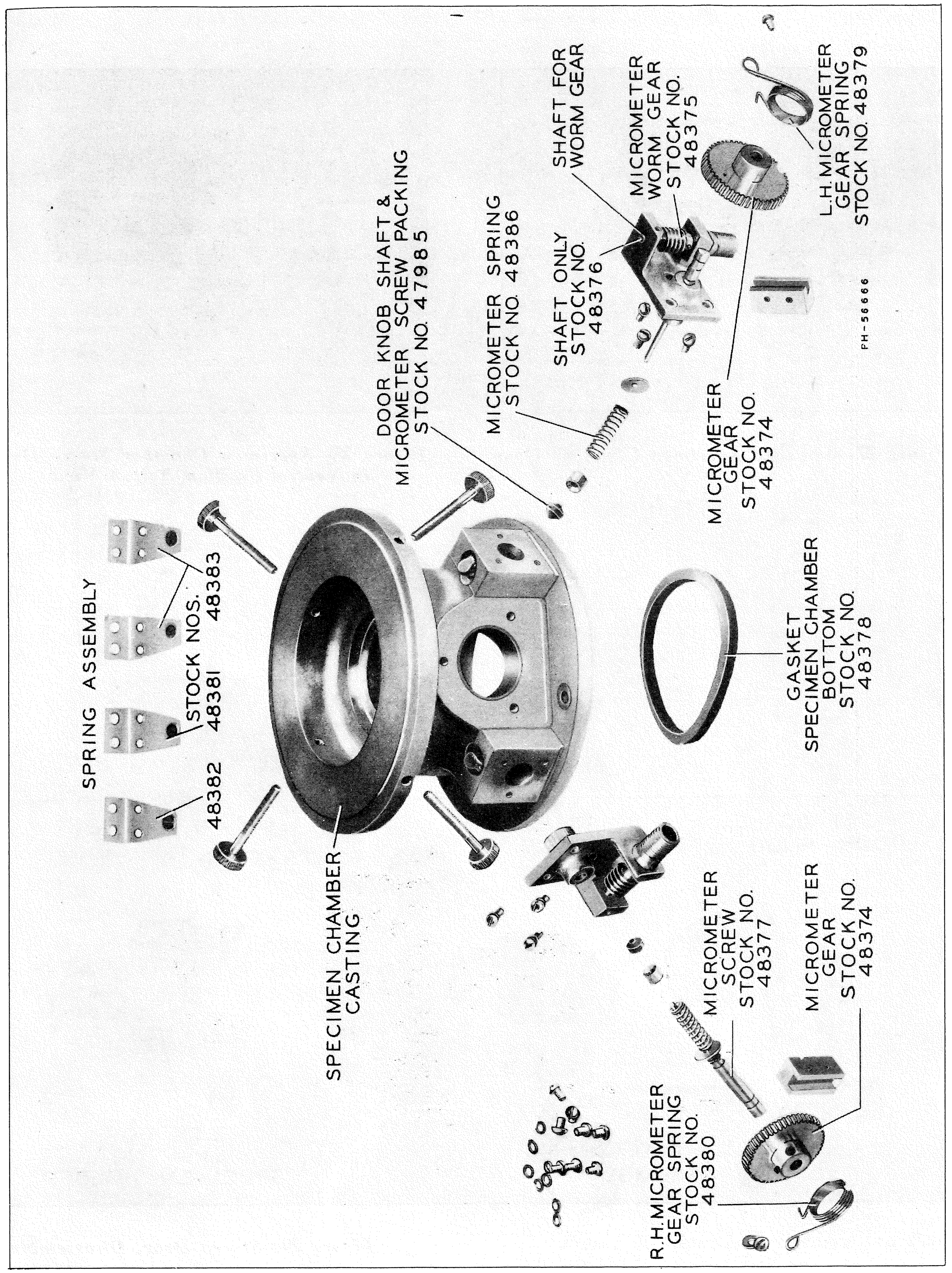

SPRING ASSEMBLY
STOCK NOS.
48381
48383
48382
SPECIMEN CHAMBER CASTING
DOOR KNOB SHAFT & MICROMETER SCREW PACKING STOCK NO. 47985
MICROMETER SPRING STOCK NO. 48386
SHAFT ONLY STOCK NO. 48376
SHAFT FOR WORM GEAR
MICROMETER WORM GEAR STOCK NO. 48375
L.H. MICROMETER GEAR SPRING STOCK NO. 48379
PH-56666
MICROMETER GEAR STOCK NO. 48374
GASKET SPECIMEN CHAMBER BOTTOM STOCK NO. 48378
MICROMETER SCREW STOCK NO. 48377
MICROMETER GEAR STOCK NO. 48374
R.H. MICROMETER GEAR SPRING STOCK NO. 48380

Figure 26—Specimen Chamber, Disassembled, Rear View

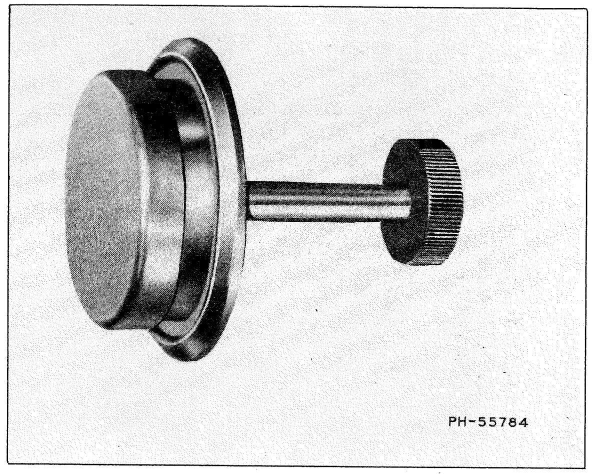


Figure 27—Standard Specimen Chamber Door

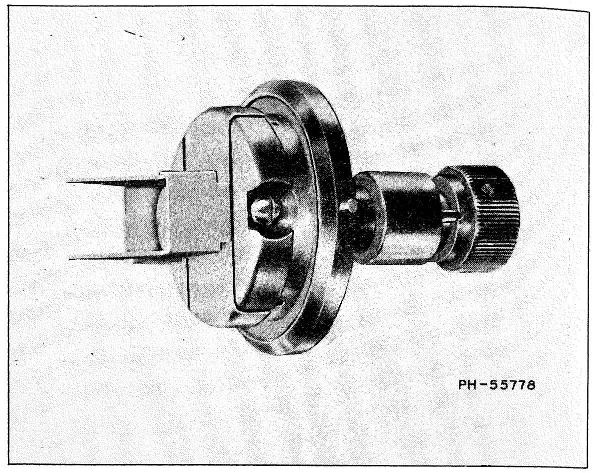


Figure 28—Specimen Chamber Stereo Door in Neutral Position, Bottom View

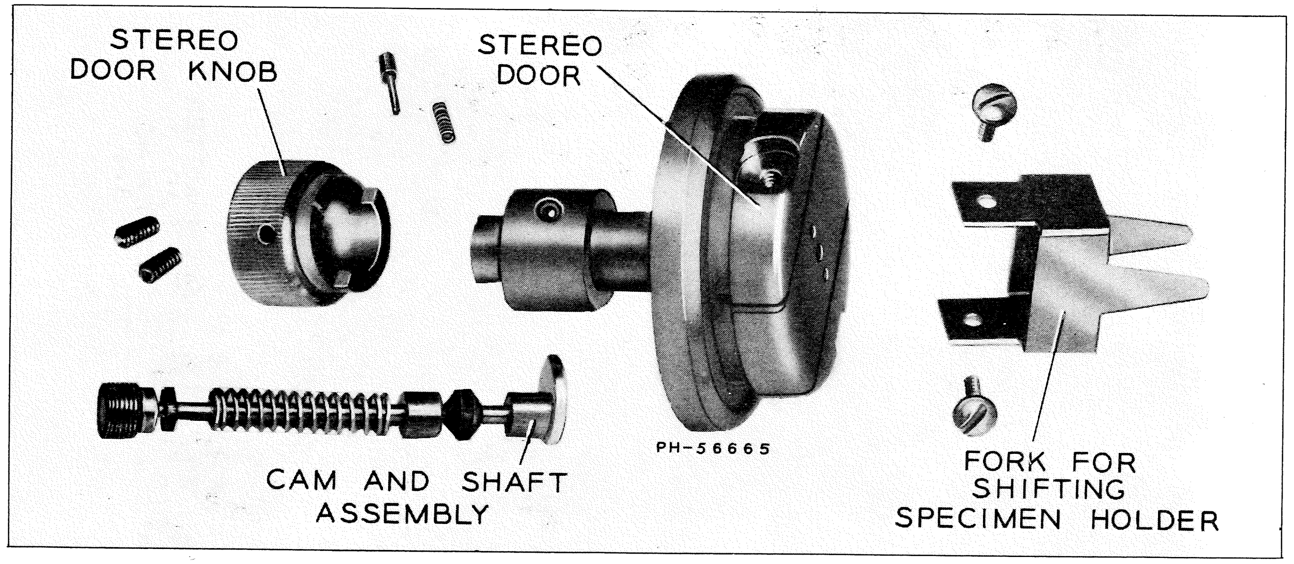

STEREO DOOR KNOB
STEREO DOOR
CAM AND SHAFT ASSEMBLY
PH-56665
FORK FOR SHIFTING SPECIMEN HOLDER

Figure 29—Stereo Door, Disassembled

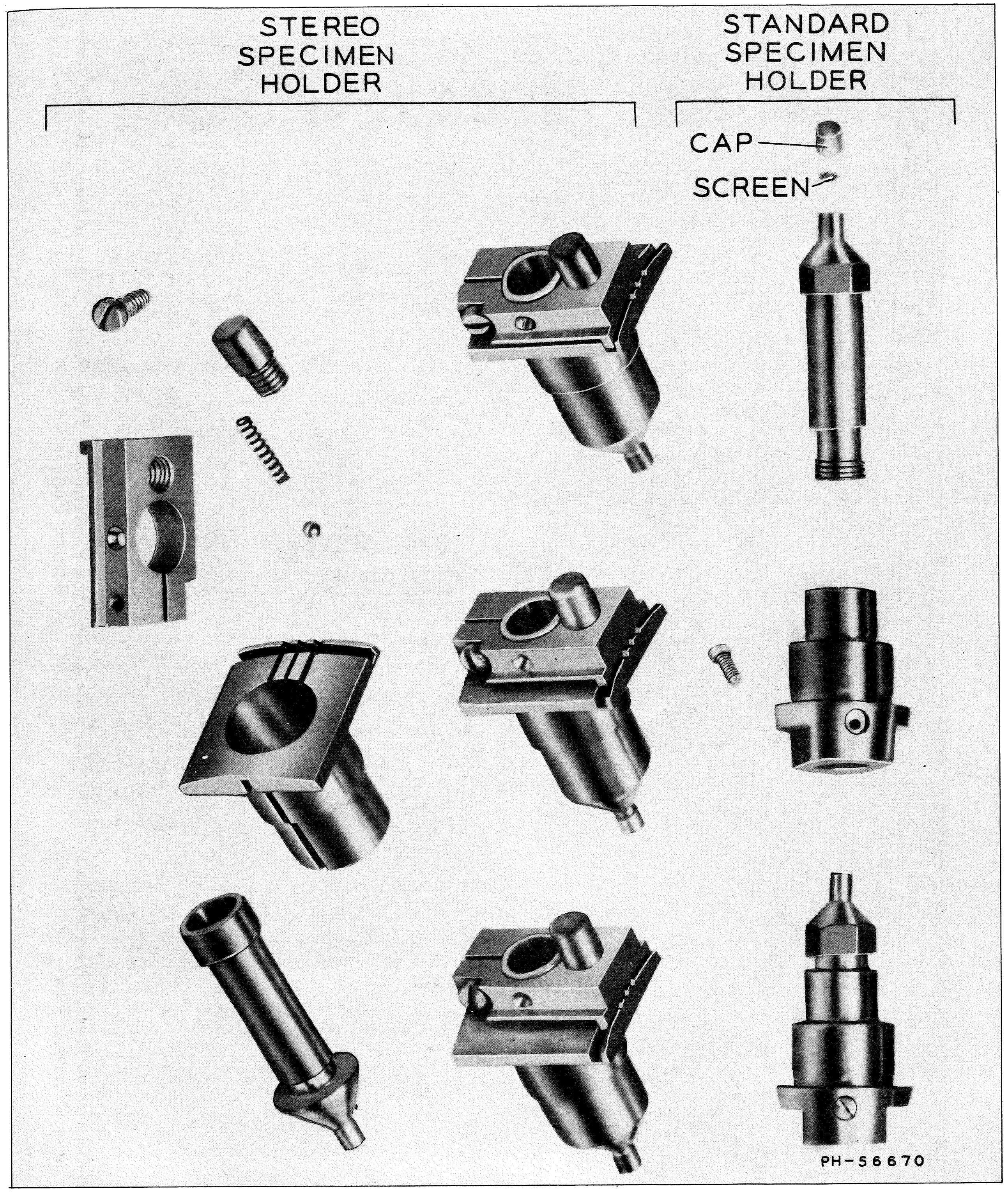

STEREO SPECIMEN HOLDER
STANDARD SPECIMEN HOLDER
CAP
SCREEN
PH-56670

Figure 30—Specimen Holders and Parts

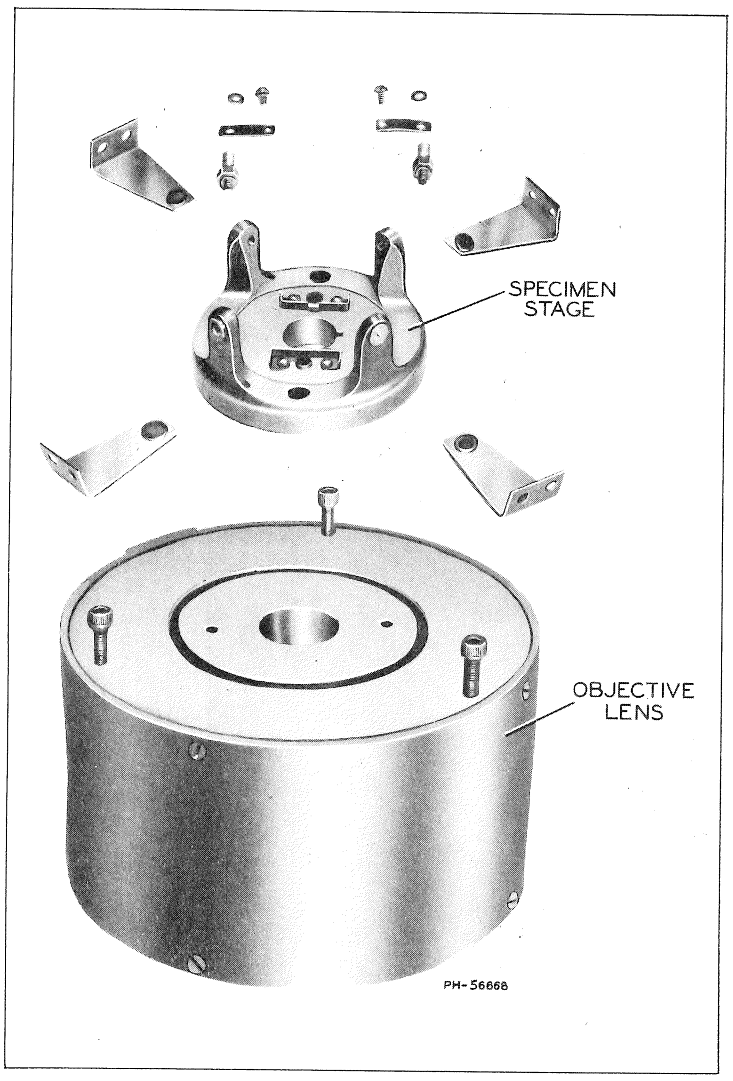

SPECIMEN STAGE
OBJECTIVE LENS
PH-56668

Figure 31—*Specimen Stage, Disassembled, and Objective Lens*

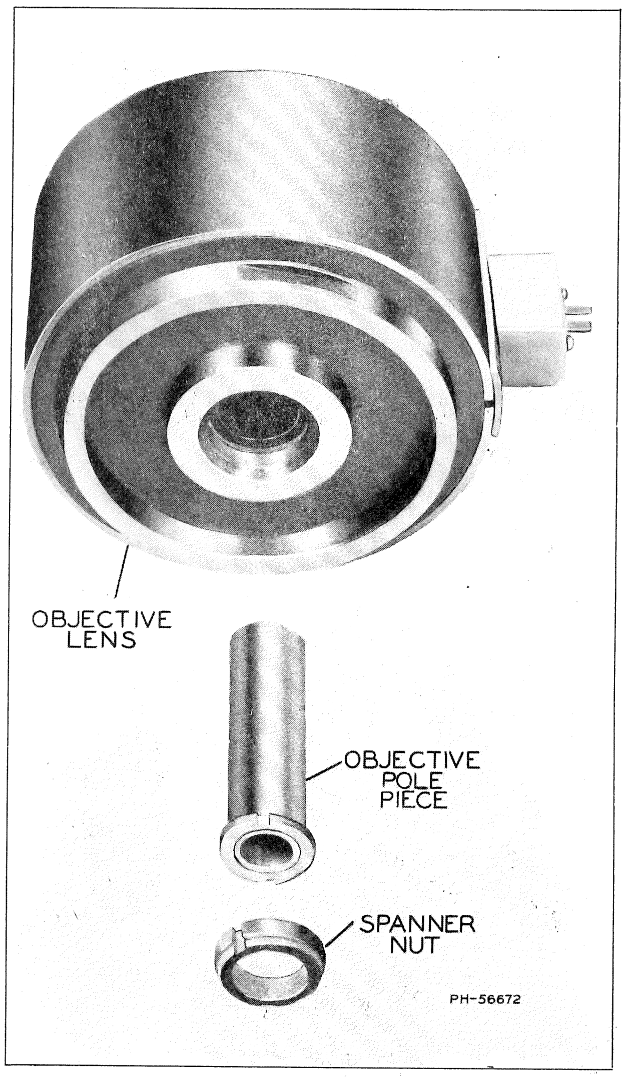

OBJECTIVE LENS
OBJECTIVE POLE PIECE
SPANNER NUT
PH-56672

Figure 32—*Objective Lens and Pole Piece, Bottom View*

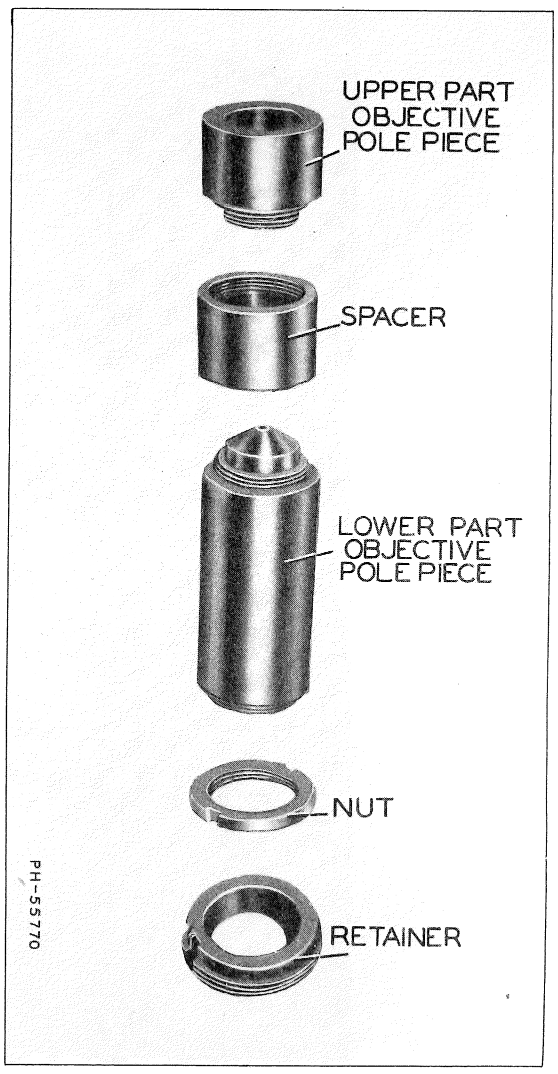

UPPER PART OBJECTIVE POLE PIECE
SPACER
LOWER PART OBJECTIVE POLE PIECE
NUT
RETAINER
PH-55770

Figure 33—*Objective Pole Piece Disassembled*

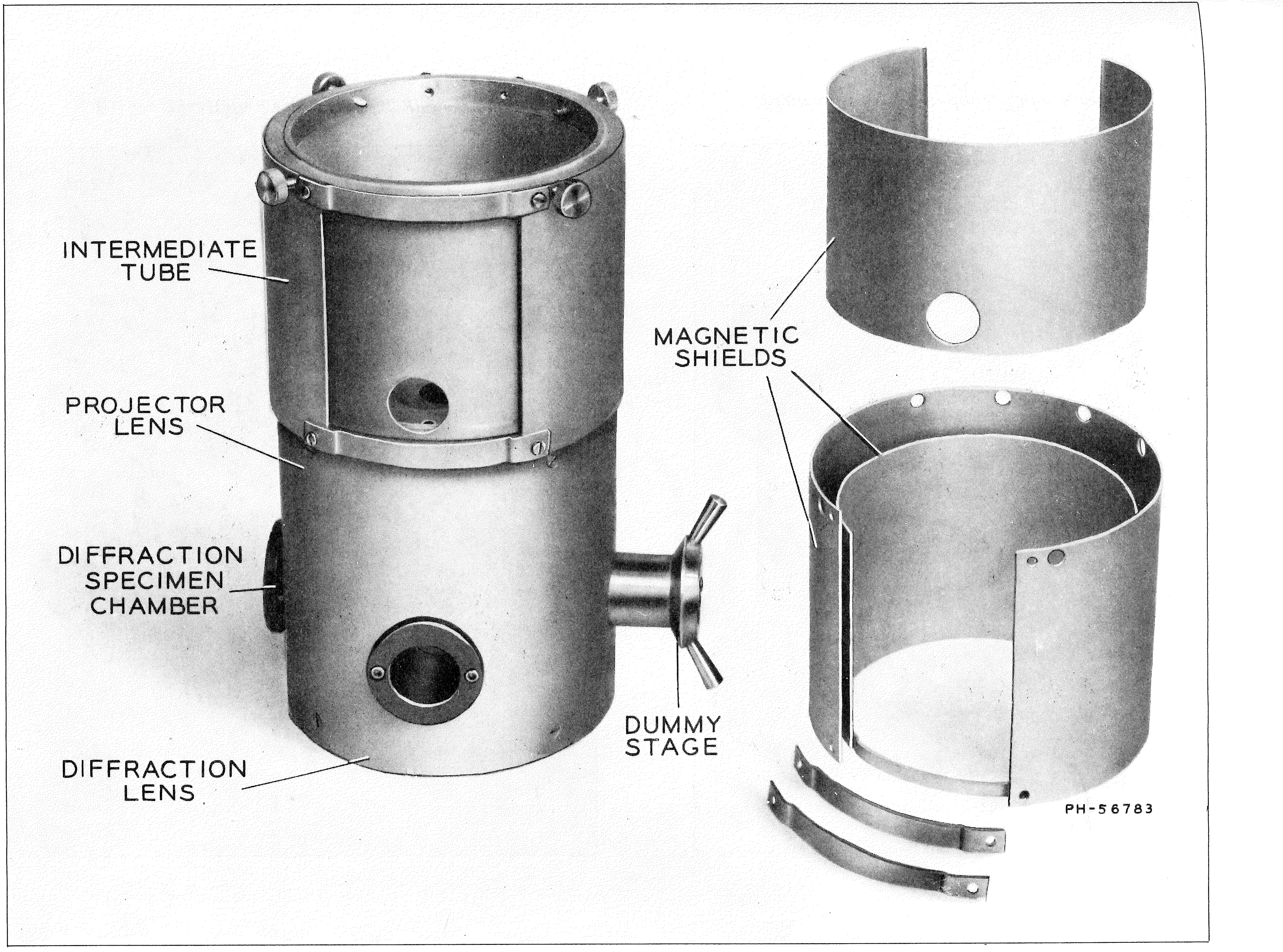

INTERMEDIATE TUBE
PROJECTOR LENS
DIFFRACTION SPECIMEN CHAMBER
DIFFRACTION LENS
MAGNETIC SHIELDS
DUMMY STAGE
PH-56783

Figure 34—*Intermediate Tube and Projector Lens*

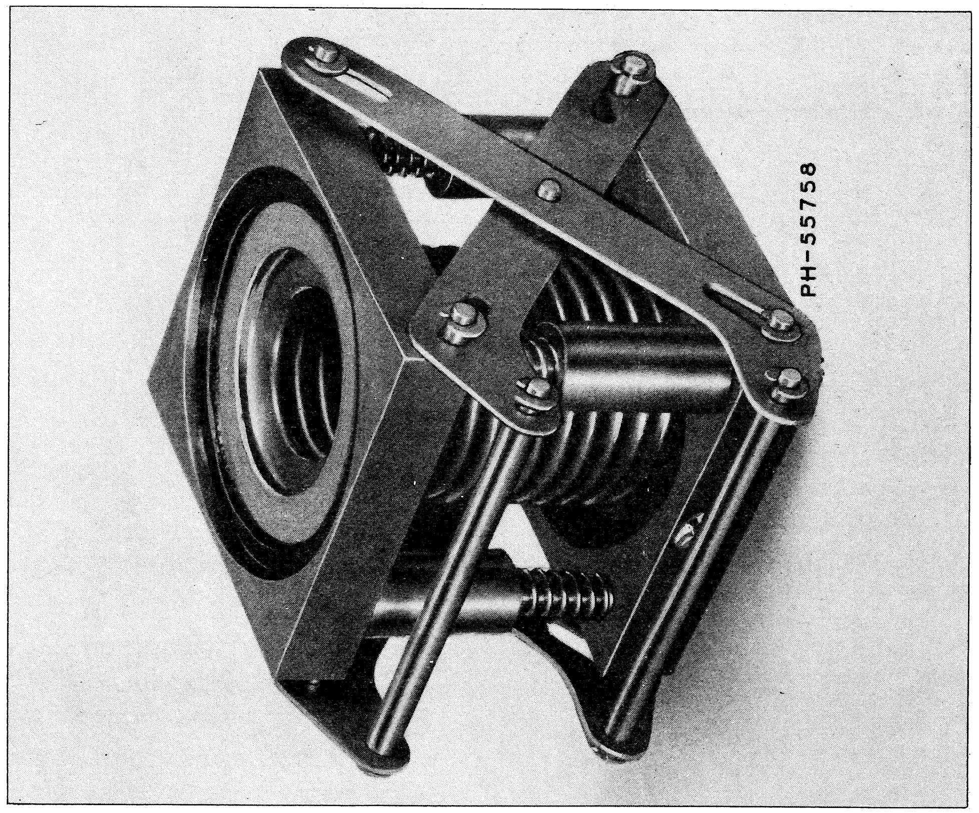


Figure 35—Bellows for Intermediate Tube

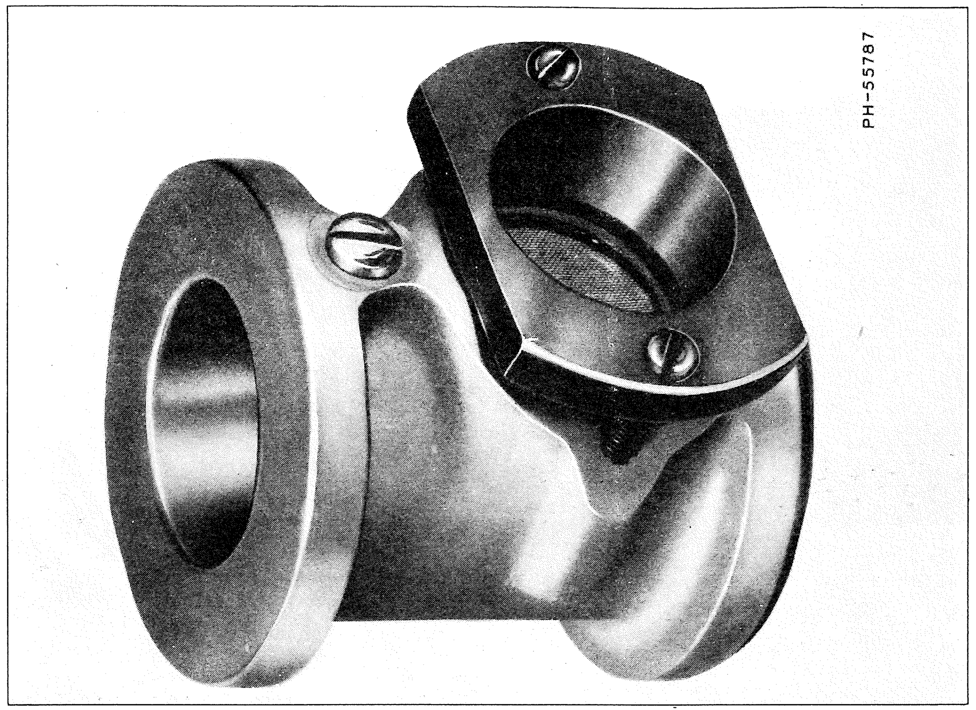


Figure 36—Intermediate Tube Casting

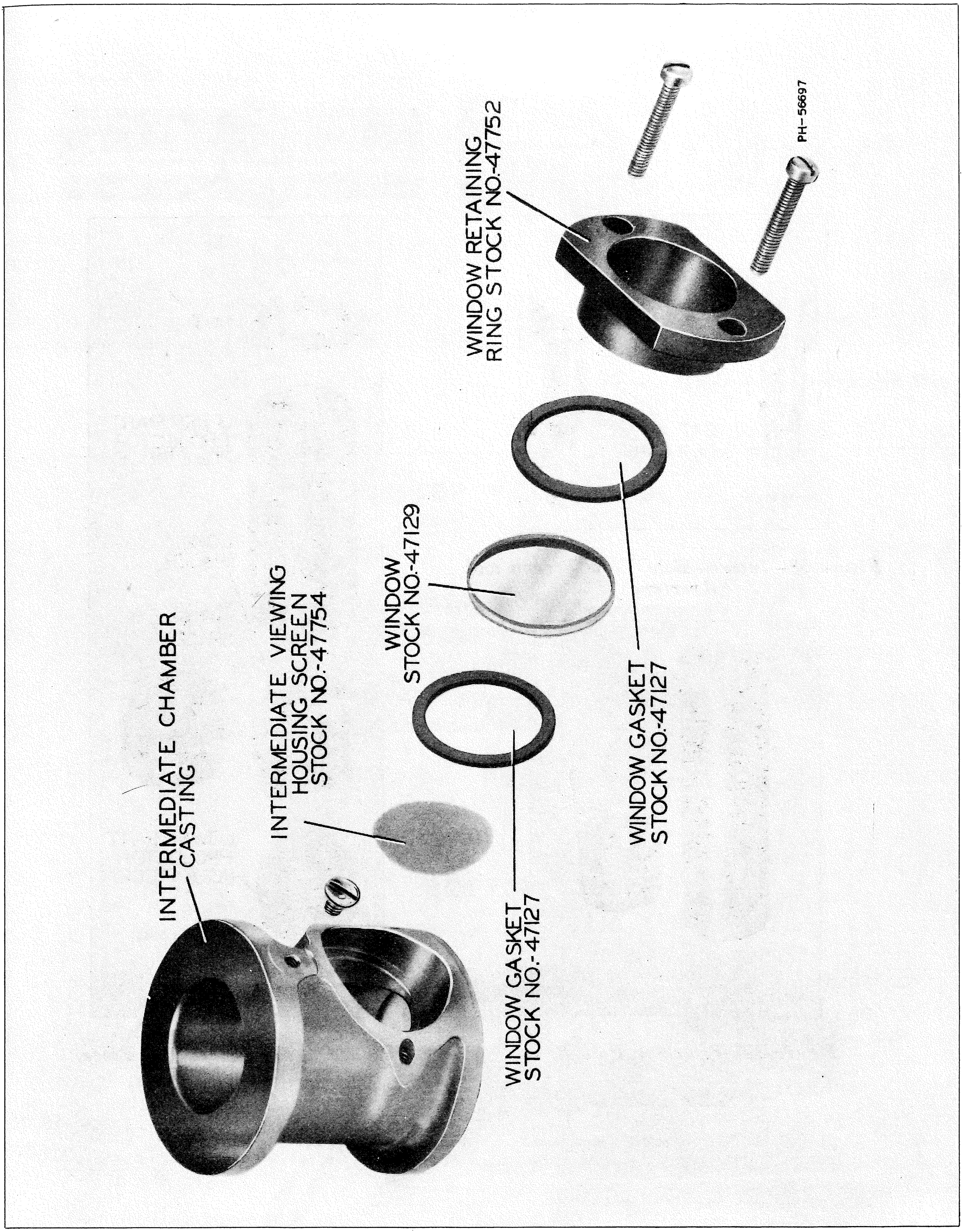

INTERMEDIATE CHAMBER CASTING
INTERMEDIATE VIEWING HOUSING SCREEN STOCK NO.-47754
WINDOW STOCK NO.-47129
WINDOW GASKET STOCK NO.-47127
WINDOW GASKET STOCK NO.-47127
WINDOW RETAINING RING STOCK NO.-47752
PH-56697

Figure 37—Intermediate Chamber, Disassembled

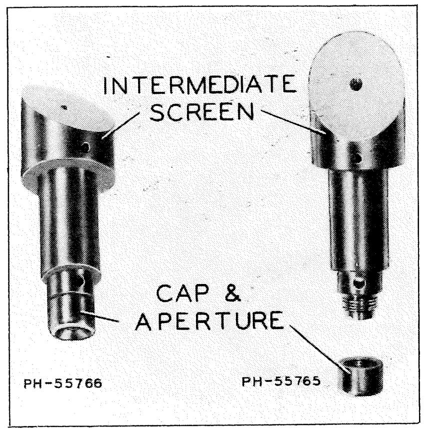

INTERMEDIATE
SCREEN
CAP &
APERTURE
PH-55766
PH-55765

Figure 38—Intermediate View Screen and Aperture

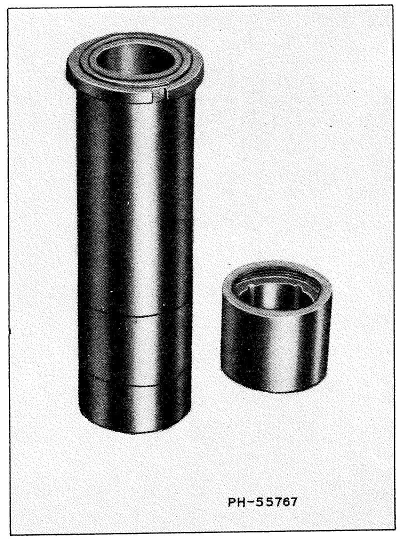


Figure 39—Projector Pole Piece

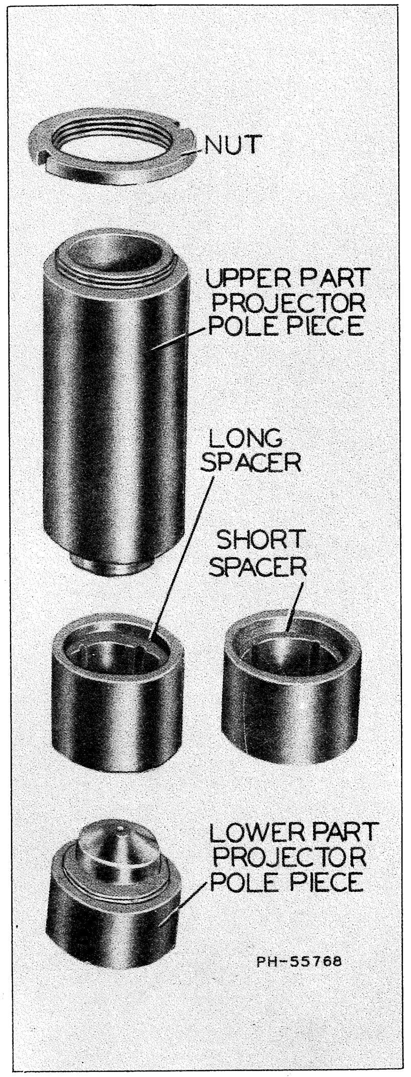

NUT
UPPER PART PROJECTOR POLE PIECE
LONG SPACER
SHORT SPACER
LOWER PART PROJECTOR POLE PIECE
PH-55768

Figure 40—Projector Pole Piece, Disassembled

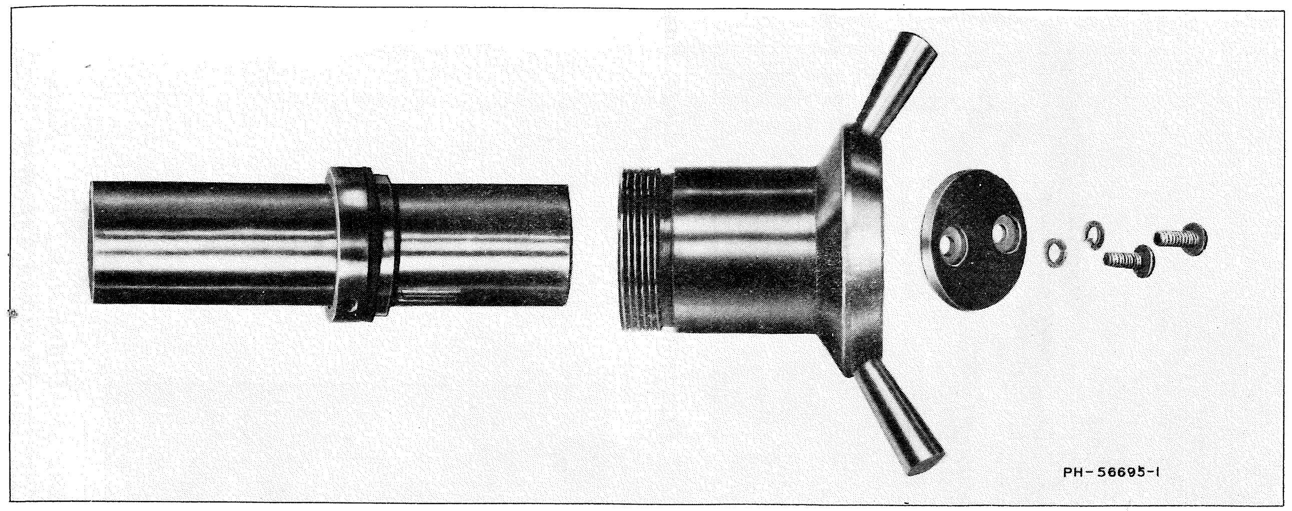


Figure 41—Dummy Diffraction Stage

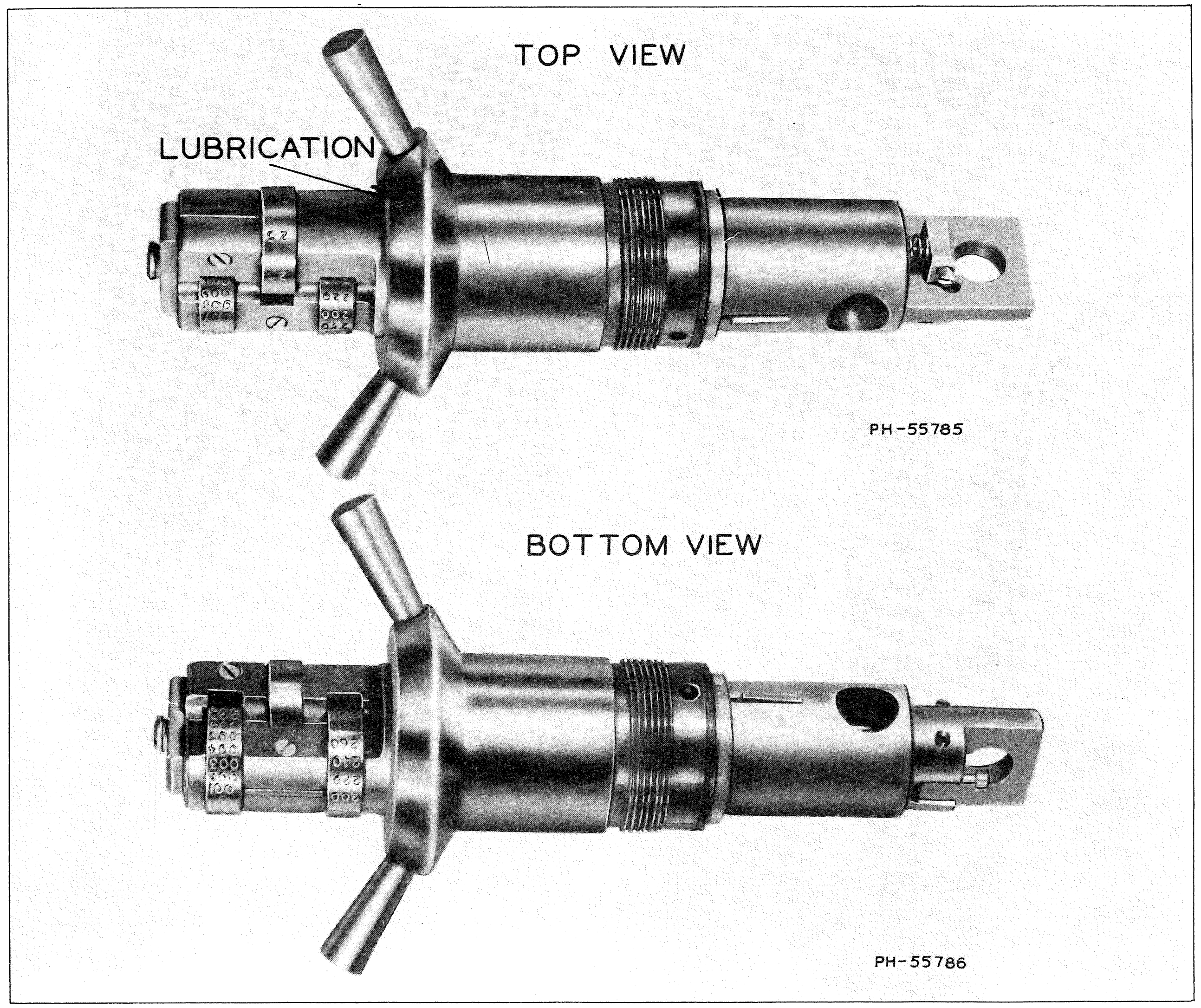

TOP VIEW
LUBRICATION
PH-55785
BOTTOM VIEW
PH-55786

Figure 42—Diffraction Stage

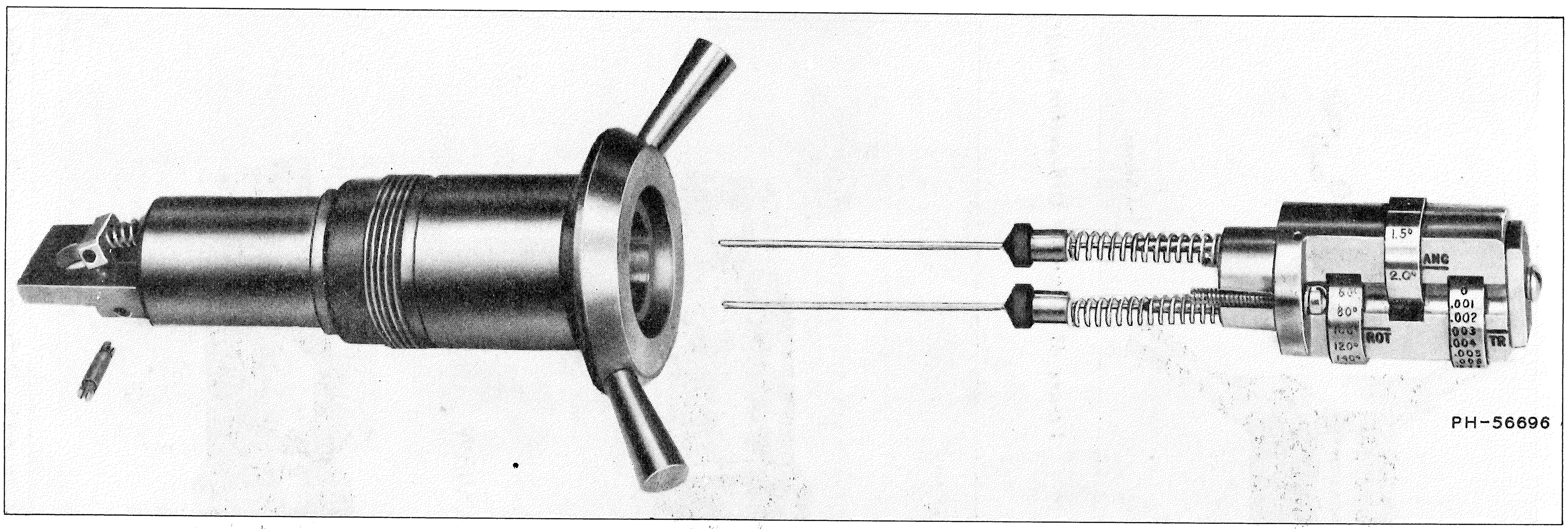

1.5°
ANG
2.0°
ROT
TR
PH-56696

Figure 43—Diffraction Stage, Partly Disassembled

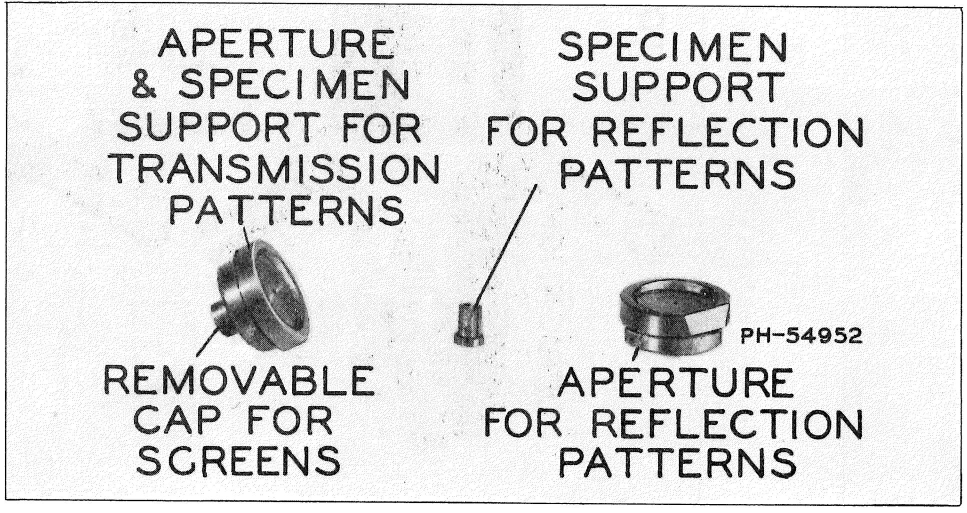

APERTURE & SPECIMEN SUPPORT FOR TRANSMISSION PATTERNS
SPECIMEN SUPPORT FOR REFLECTION PATTERNS
REMOVABLE CAP FOR SCREENS
APERTURE FOR REFLECTION PATTERNS
PH-54952

Figure 44—Diffraction Unit, Apertures and Specimen Supports

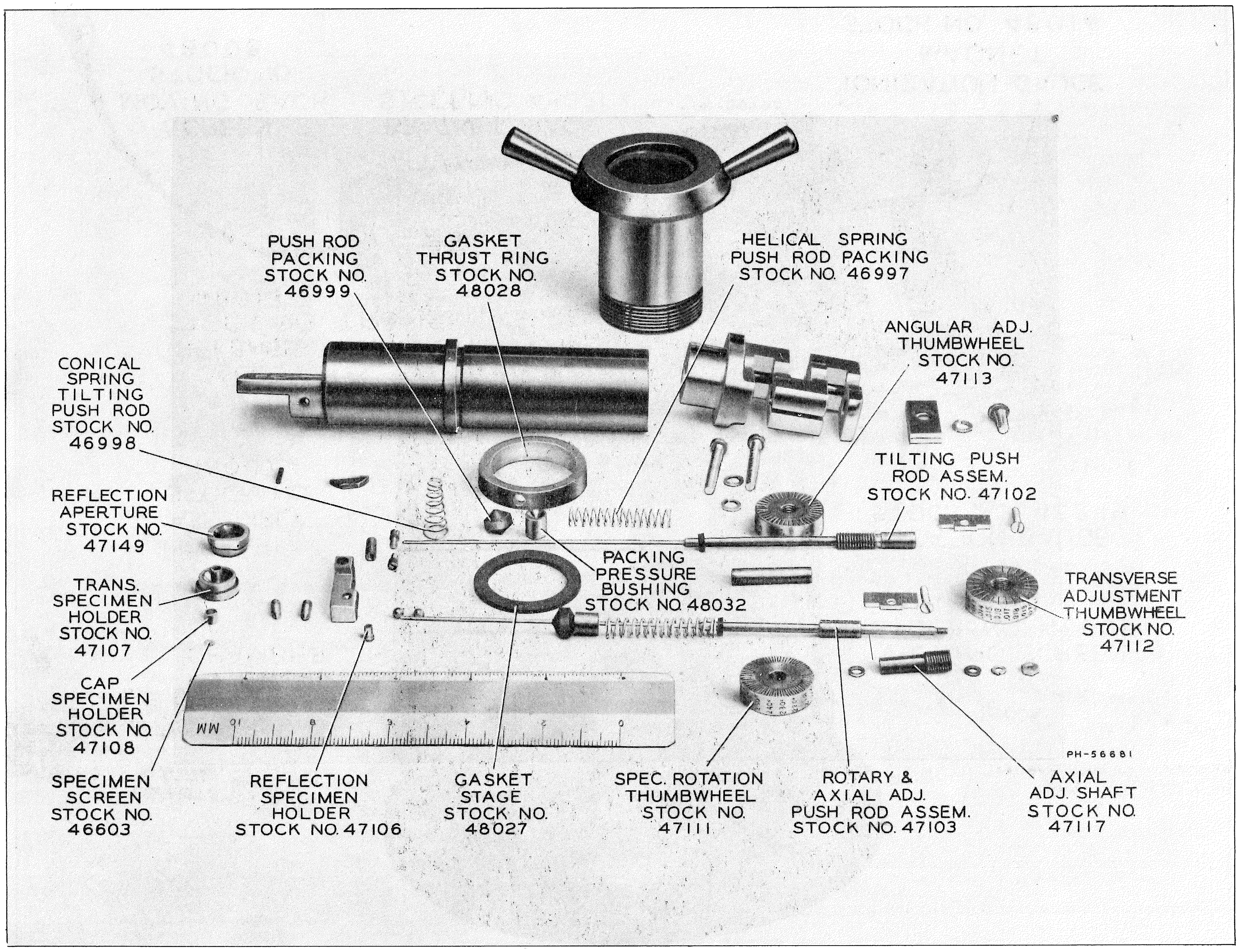

PUSH ROD PACKING STOCK NO. 46999
GASKET THRUST RING STOCK NO. 48028
HELICAL SPRING PUSH ROD PACKING STOCK NO. 46997
ANGULAR ADJ. THUMBWHEEL STOCK NO. 47113
CONICAL SPRING TILTING PUSH ROD STOCK NO. 46998
TILTING PUSH ROD ASSEM. STOCK NO. 47102
REFLECTION APERTURE STOCK NO. 47149
PACKING PRESSURE BUSHING STOCK NO. 48032
TRANS. SPECIMEN HOLDER STOCK NO. 47107
TRANSVERSE ADJUSTMENT THUMBWHEEL STOCK NO. 47112
CAP SPECIMEN HOLDER STOCK NO. 47108
MM
PH-56681
SPECIMEN SCREEN STOCK NO. 46603
REFLECTION SPECIMEN HOLDER STOCK NO. 47106
GASKET STAGE STOCK NO. 48027
SPEC. ROTATION THUMBWHEEL STOCK NO. 47111
ROTARY & AXIAL ADJ. PUSH ROD ASSEM. STOCK NO. 47103
AXIAL ADJ. SHAFT STOCK NO. 47117

Figure 45—Diffraction Stage, Disassembled

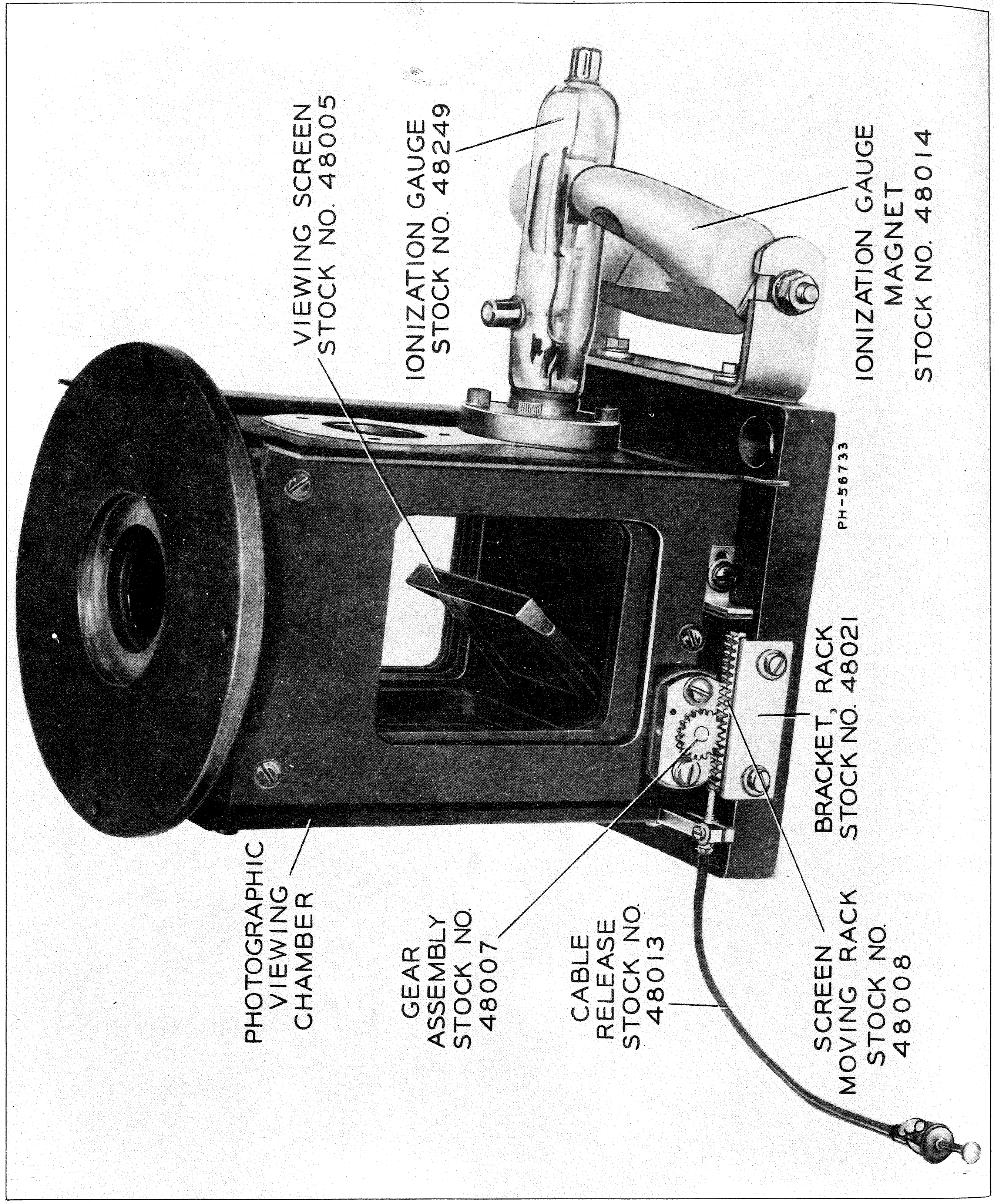

VIEWING SCREEN STOCK NO. 48005
IONIZATION GAUGE STOCK NO. 48249
IONIZATION GAUGE MAGNET STOCK NO. 48014
PH-56733
BRACKET, RACK STOCK NO. 48021
PHOTOGRAPHIC VIEWING CHAMBER
GEAR ASSEMBLY STOCK NO. 48007
CABLE RELEASE STOCK NO. 48013
SCREEN MOVING RACK STOCK NO. 48008

Figure 46—Final Viewing Chamber, Right Side View

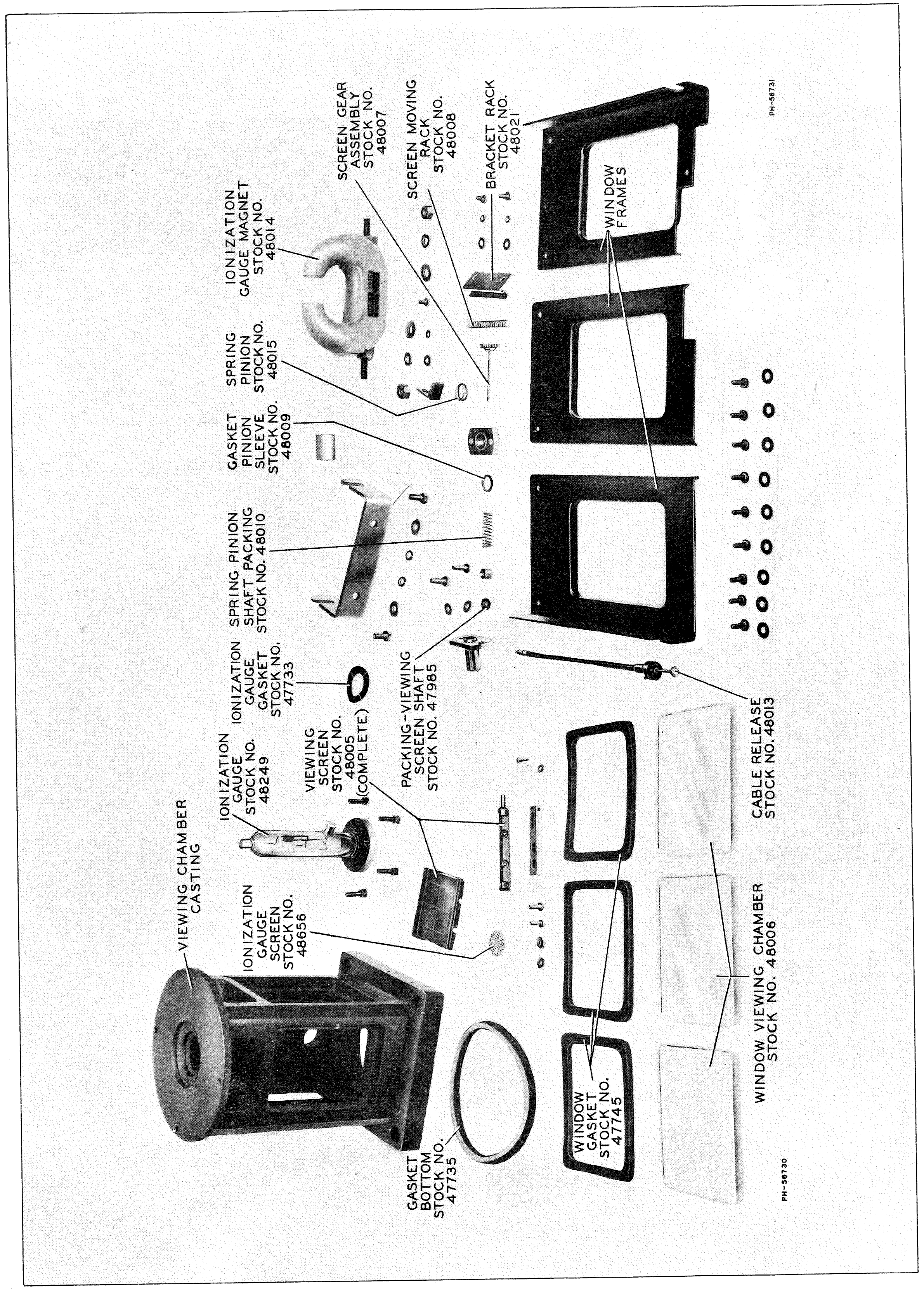

SCREEN GEAR ASSEMBLY STOCK NO. 48007
SCREEN MOVING RACK STOCK NO. 48008
BRACKET RACK STOCK NO. 48021
IONIZATION GAUGE MAGNET STOCK NO. 48014
SPRING PINION STOCK NO. 48015
GASKET PINION SLEEVE STOCK NO. 48009
SPRING PINION SHAFT PACKING STOCK NO. 48010
IONIZATION GAUGE GASKET STOCK NO. 47733
IONIZATION GAUGE STOCK NO. 48249
VIEWING SCREEN STOCK NO. 48005 (COMPLETE)
PACKING-VIEWING SCREEN SHAFT STOCK NO. 47985
VIEWING CHAMBER CASTING
IONIZATION GAUGE SCREEN STOCK NO. 48656
WINDOW FRAMES
PH-58731
CABLE RELEASE STOCK NO. 48013
WINDOW VIEWING CHAMBER STOCK NO. 48006
WINDOW GASKET STOCK NO. 47745
GASKET BOTTOM STOCK NO. 47735
PH-58730

Figure 47—Final Viewing Chamber, Disassembled

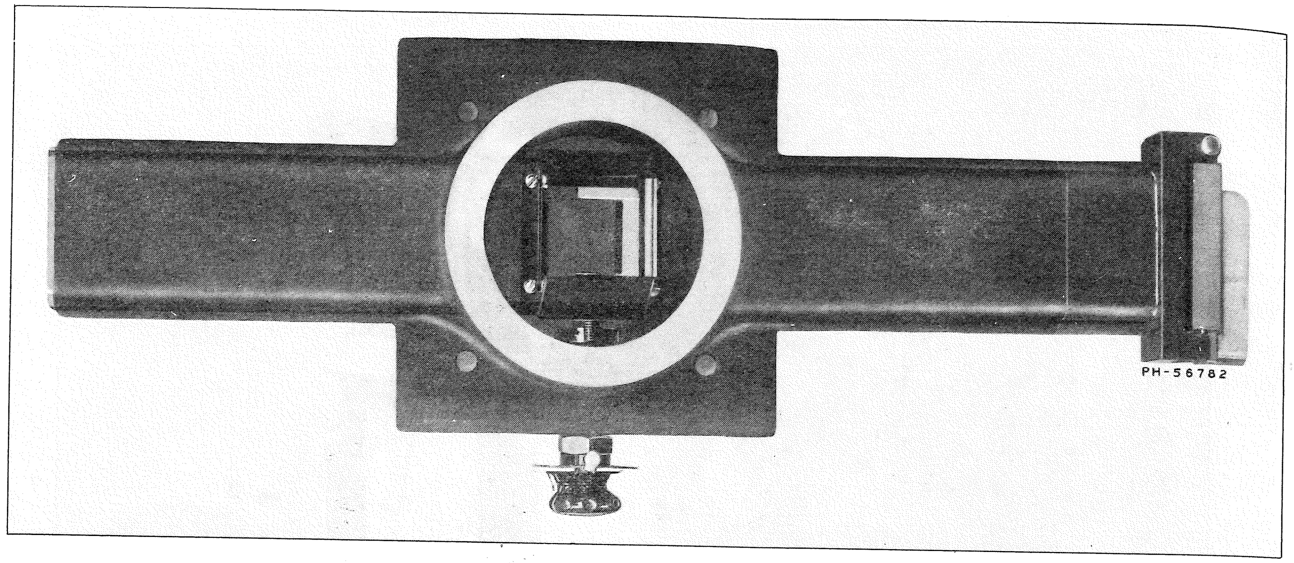


Figure 48—*Photographic Chamber, Top View*

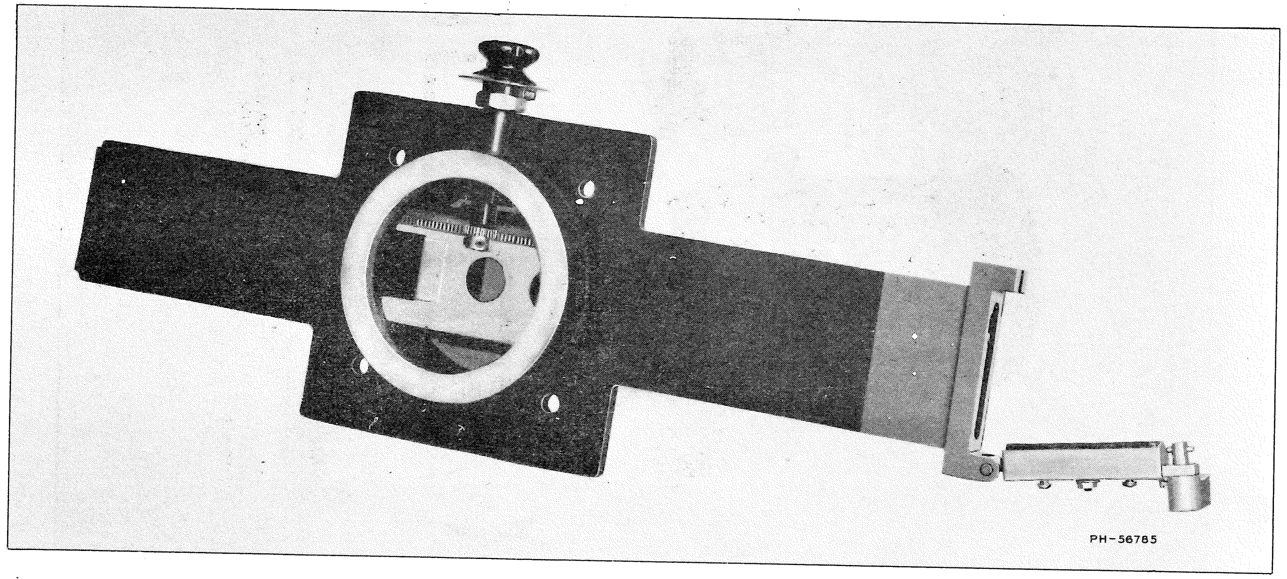


Figure 49—*Photographic Chamber, Bottom View*

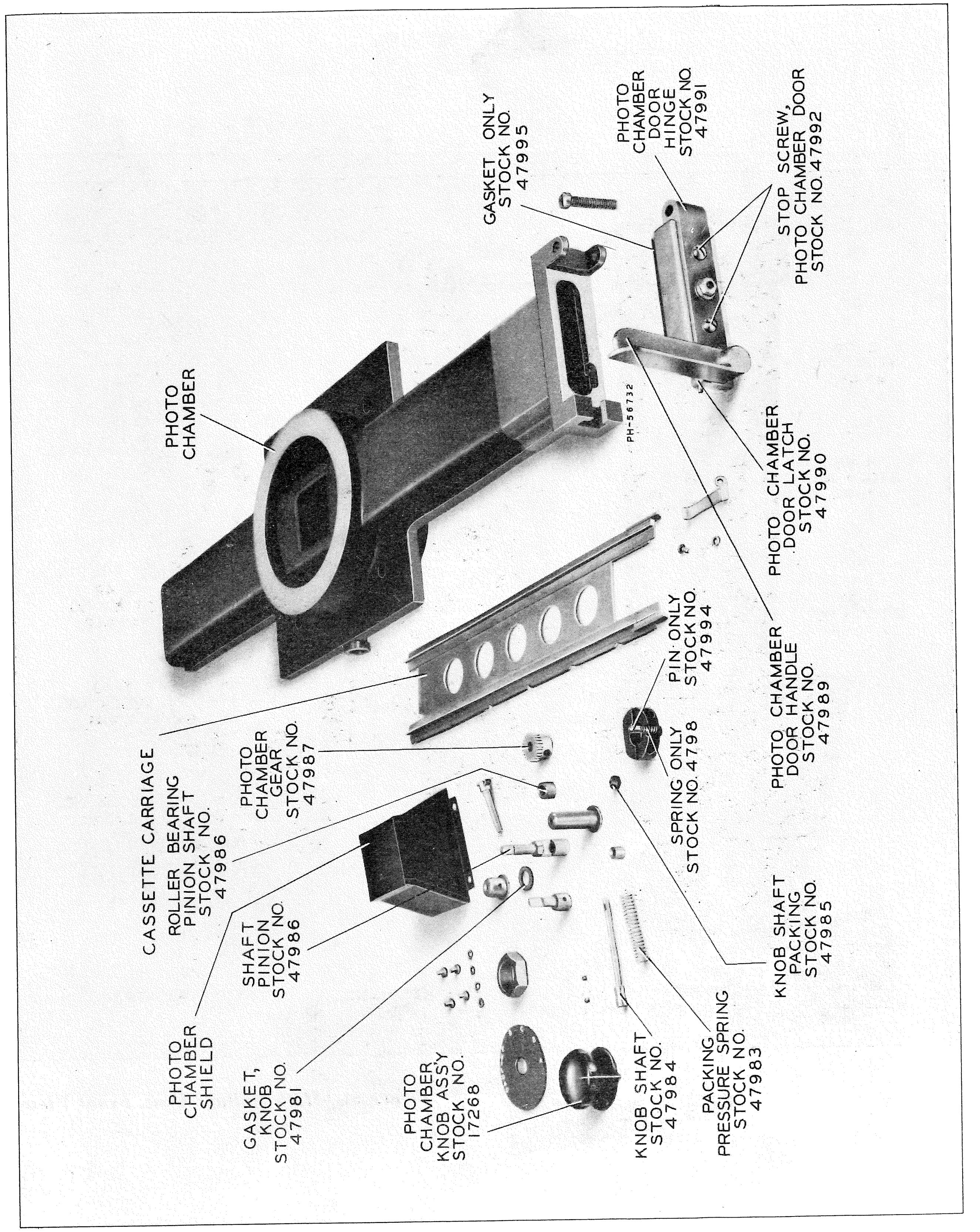


PHOTO CHAMBER
GASKET ONLY STOCK NO. 47995
PHOTO CHAMBER DOOR HINGE STOCK NO. 47991
STOP SCREW, PHOTO CHAMBER DOOR STOCK NO. 47992
PH-56732
PHOTO CHAMBER DOOR LATCH STOCK NO. 47990
PHOTO CHAMBER DOOR HANDLE STOCK NO. 47989
PIN ONLY STOCK NO. 47994
SPRING ONLY STOCK NO. 4798
KNOB SHAFT PACKING STOCK NO. 47985
PACKING PRESSURE SPRING STOCK NO. 47983
KNOB SHAFT STOCK NO. 47984
PHOTO CHAMBER KNOB ASSY STOCK NO. 17268
GASKET, KNOB STOCK NO. 47981
PHOTO CHAMBER SHIELD
SHAFT PINION STOCK NO. 47986
CASSETTE CARRIAGE
ROLLER BEARING PINION SHAFT STOCK NO. 47986
PHOTO CHAMBER GEAR STOCK NO. 47987

Figure 50—*Photographic Chamber, Disassembled*

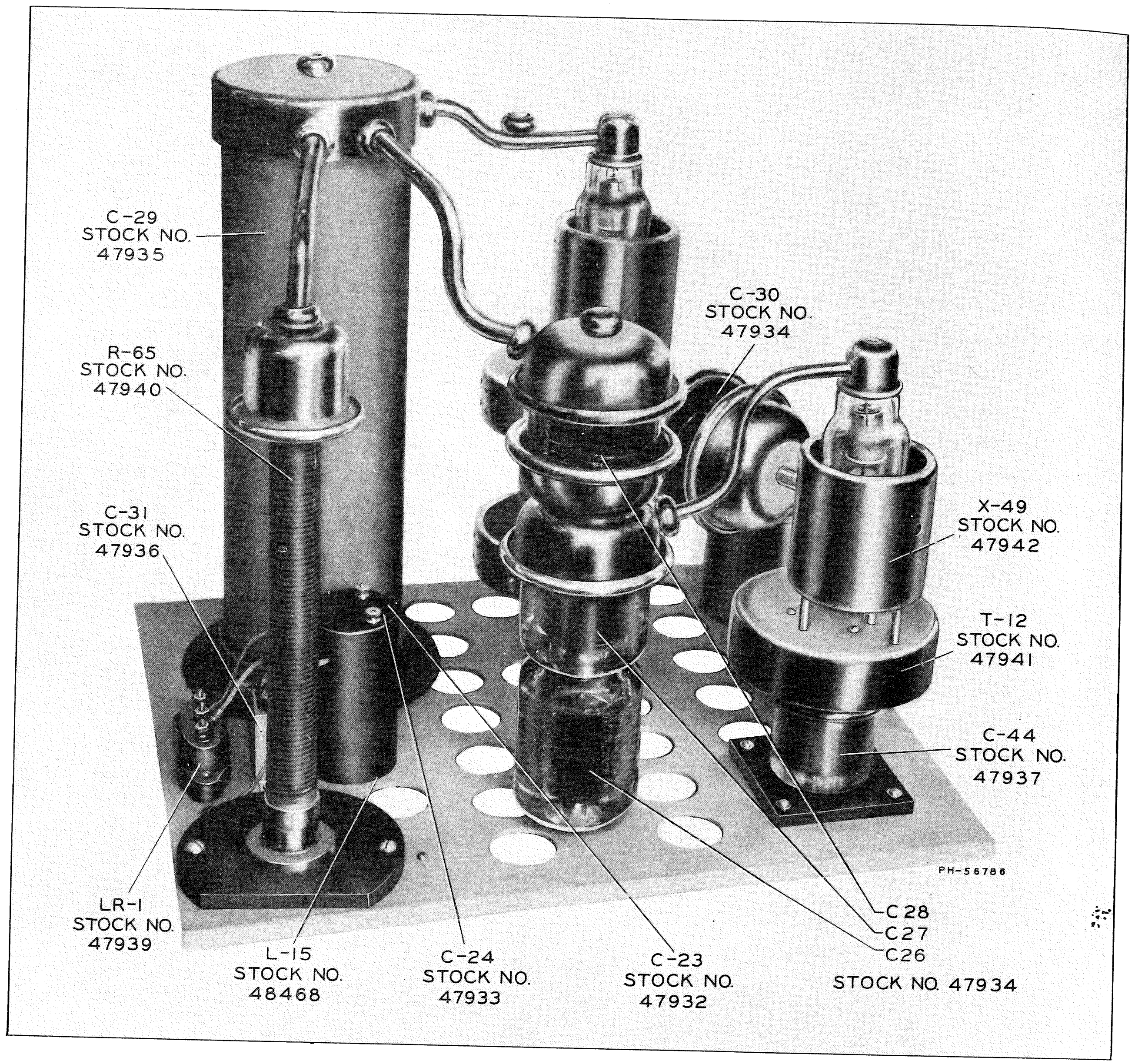

C-29
STOCK NO.
47935
R-65
STOCK NO.
47940
C-31
STOCK NO.
47936
LR-1
STOCK NO.
47939
L-15
STOCK NO.
48468
C-24
STOCK NO.
47933
C-23
STOCK NO.
47932
C-30
STOCK NO.
47934
X-49
STOCK NO.
47942
T-12
STOCK NO.
47941
C-44
STOCK NO.
47937
C28
C27
C26
STOCK NO. 47934
PH-56786

Figure 51—*High Voltage Unit, Front View*

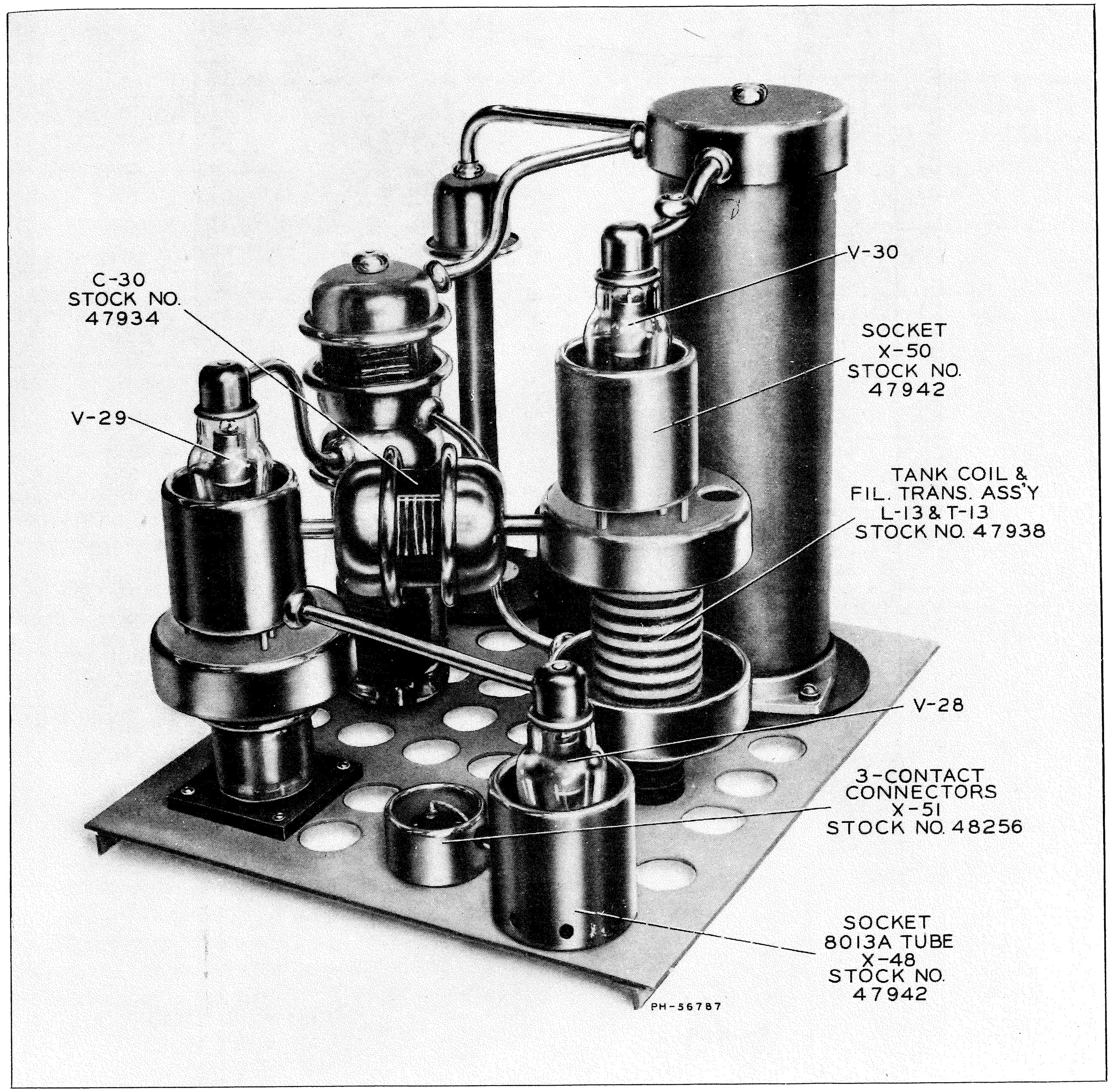

C-30
STOCK NO.
47934
V-29
V-30
SOCKET
X-50
STOCK NO.
47942
TANK COIL &
FIL. TRANS. ASS'Y
L-13 & T-13
STOCK NO. 47938
V-28
3-CONTACT
CONNECTORS
X-51
STOCK NO. 48256
SOCKET
8013A TUBE
X-48
STOCK NO.
47942
PH-56787

Figure 52—*High Voltage Unit, Rear Right Side View*

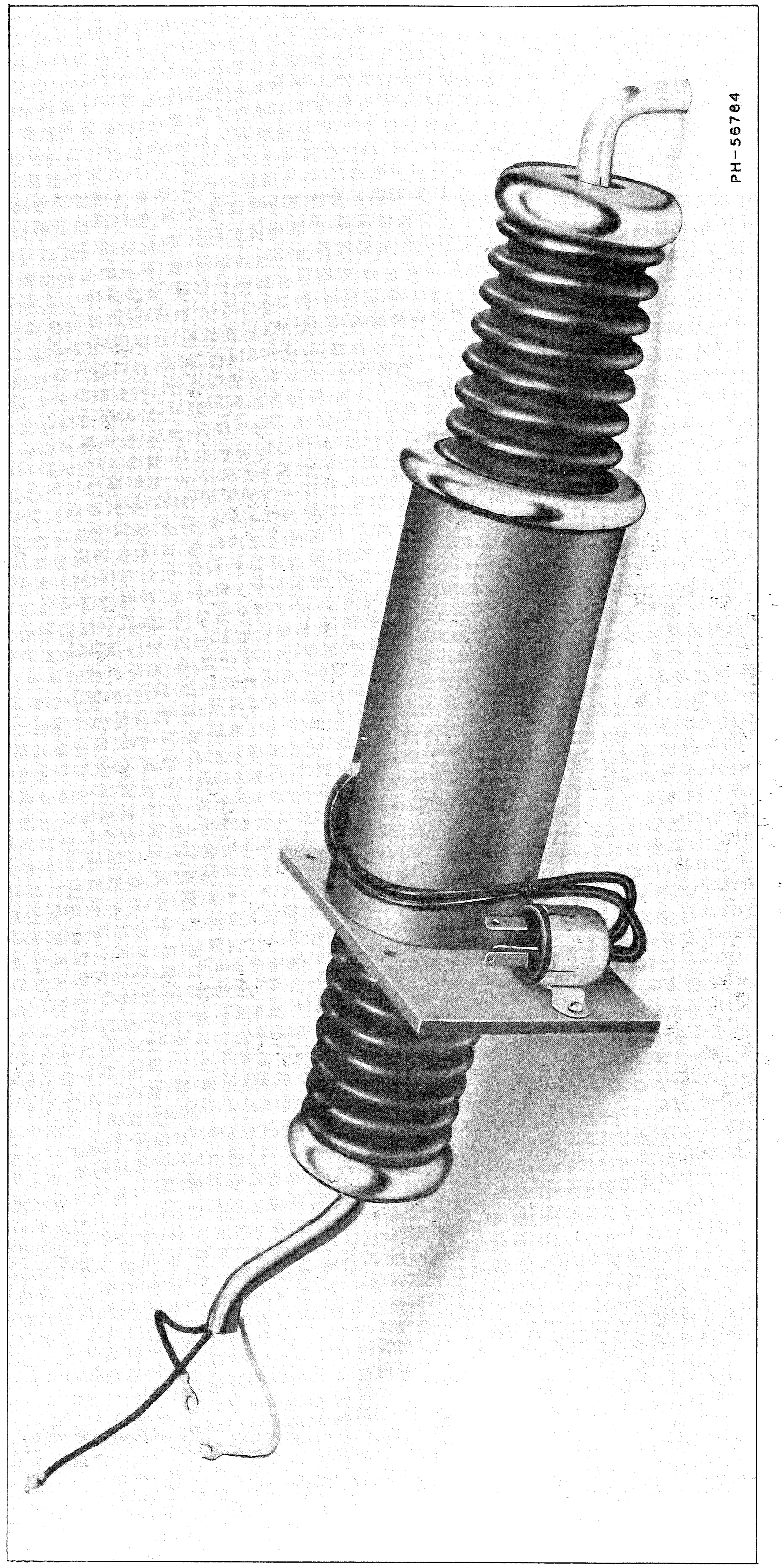


Figure 53—High Voltage Bushing

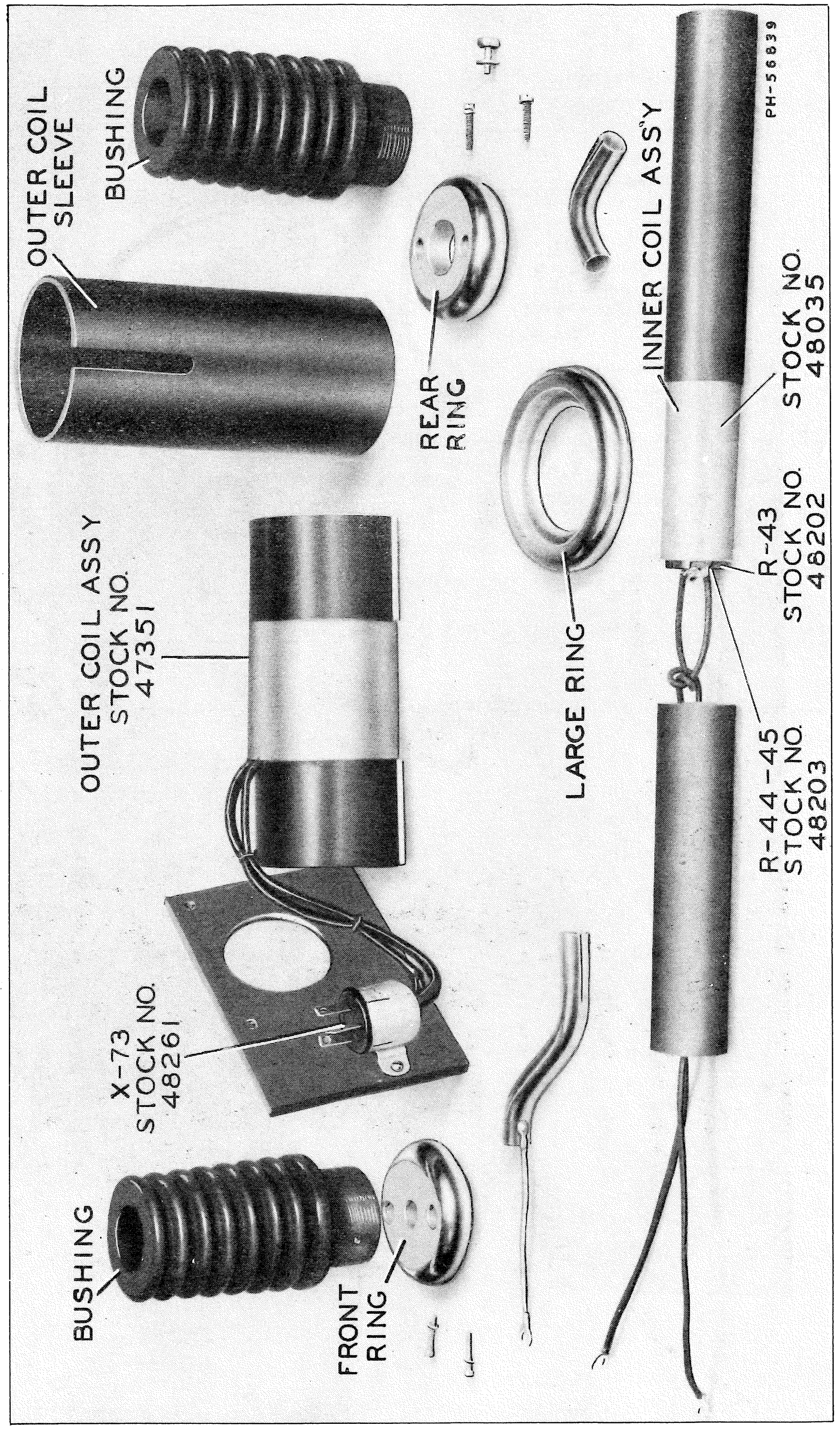

OUTER COIL SLEEVE
BUSHING
REAR RING
INNER COIL ASS'Y
STOCK NO. 48035
PH-56839
OUTER COIL ASSY STOCK NO. 47351
LARGE RING
R-43 STOCK NO. 48202
R-44-45 STOCK NO. 48203
X-73 STOCK NO. 48261
BUSHING
FRONT RING

Figure 54—High Voltage Bushing, Disassembled

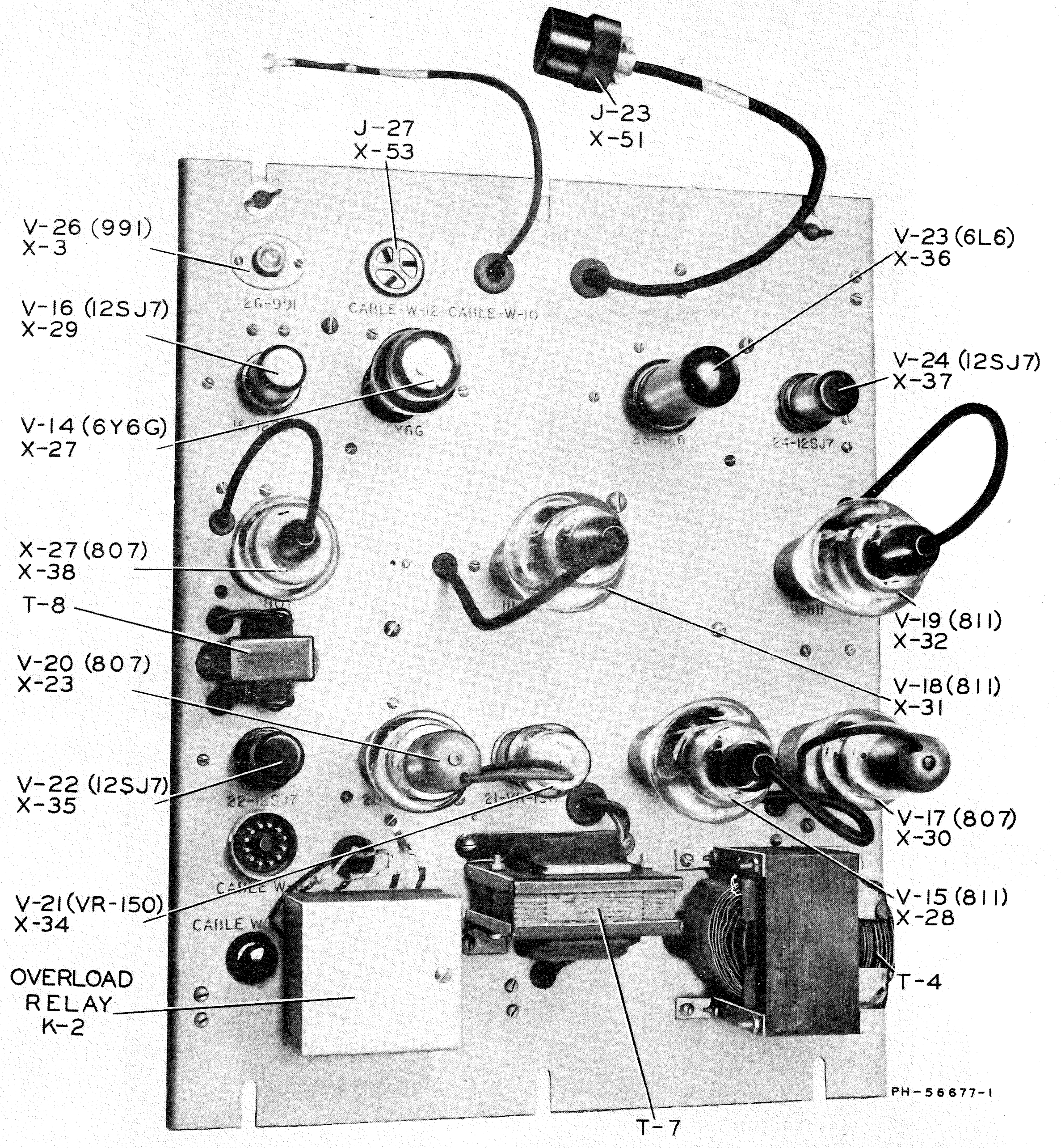

J-27
X-53
J-23
X-51
V-26 (991)
X-3
26-991
CABLE-W-12
CABLE-W-10
V-16 (12SJ7)
X-29
V-14 (6Y6G)
X-27
X-27(807)
X-38
T-8
V-20 (807)
X-23
V-22 (12SJ7)
X-35
V-21(VR-150)
X-34
OVERLOAD
RELAY
K-2
T-7
V-23 (6L6)
X-36
V-24 (12SJ7)
X-37
V-19 (811)
X-32
V-18(811)
X-31
V-17 (807)
X-30
V-15 (811)
X-28
T-4
PH-56677-1

Figure 55—Top Chassis, Front View

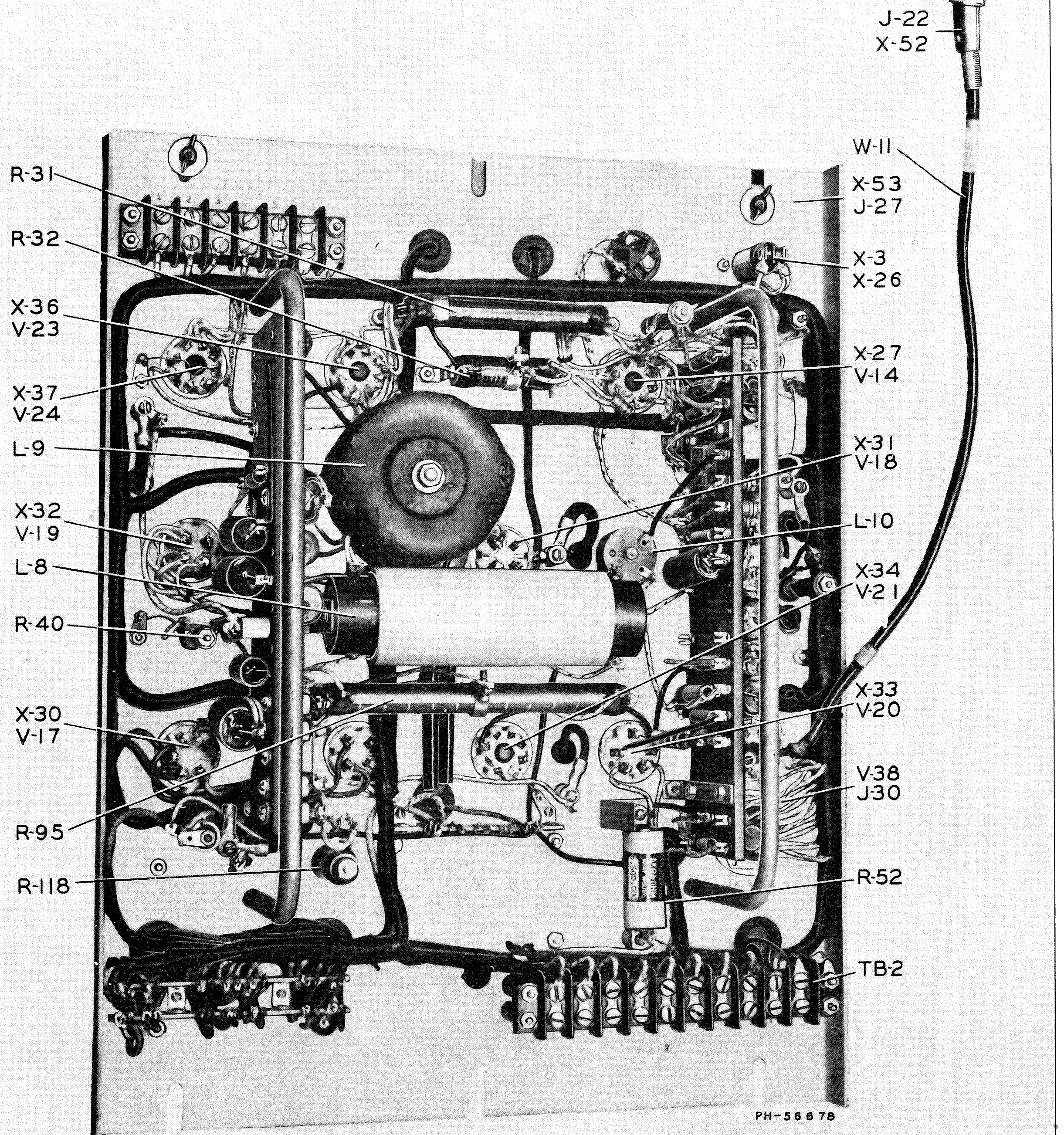

J-22
X-52
W-11
X-53
J-27
X-3
X-26
X-27
V-14
X-31
V-18
L-10
X-34
V-21
X-33
V-20
V-38
J-30
R-52
TB-2
R-31
R-32
X-36
V-23
X-37
V-24
L-9
X-32
V-19
L-8
R-40
X-30
V-17
R-95
R-118
PH-56678

Figure 56—Top Chassis, Rear View

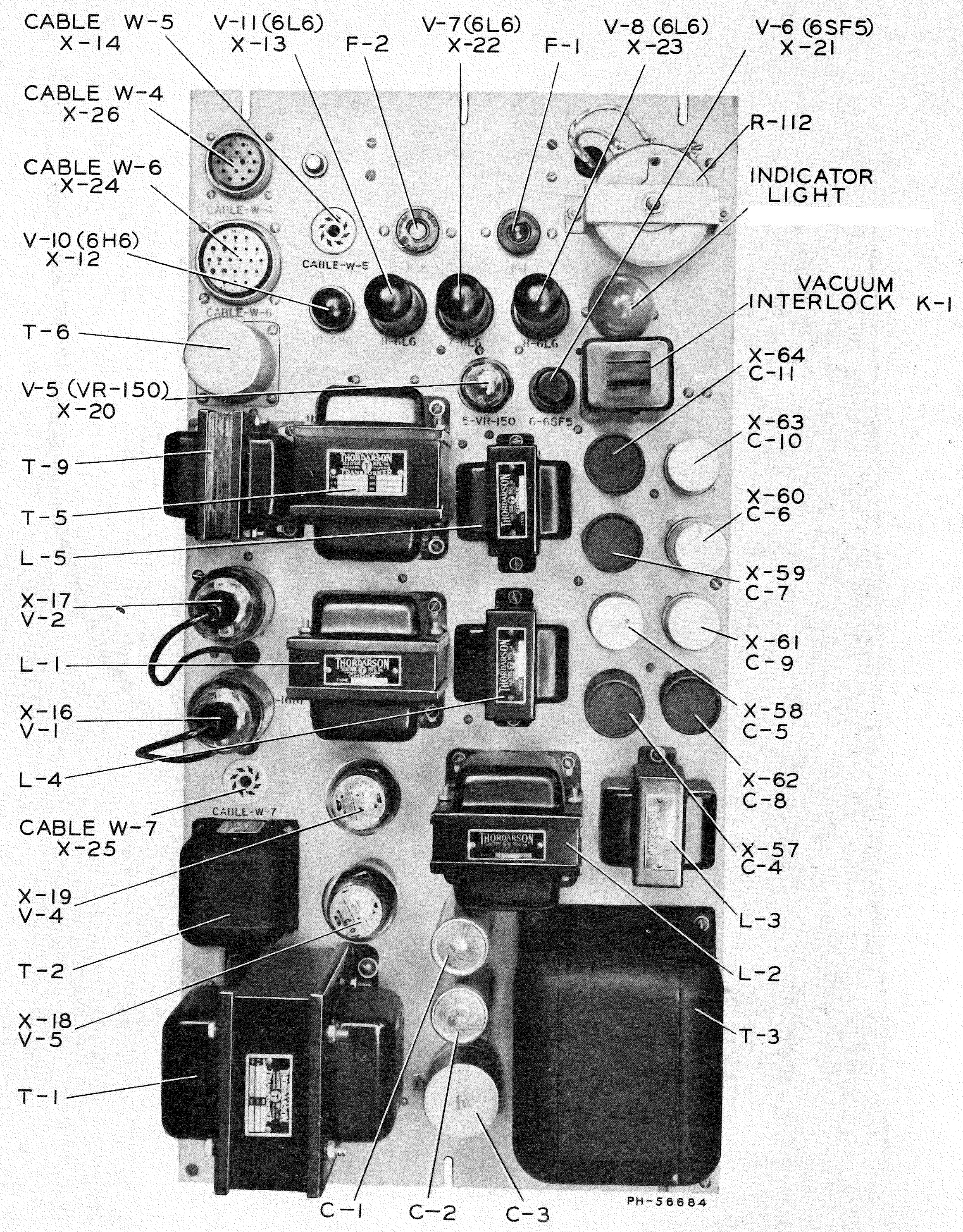

CABLE W-5
X-14
V-11 (6L6)
X-13
F-2
V-7 (6L6)
X-22
F-1
V-8 (6L6)
X-23
V-6 (6SF5)
X-21
CABLE W-4
X-26
R-112
CABLE W-6
X-24
INDICATOR
LIGHT
V-10 (6H6)
X-12
VACUUM
INTERLOCK K-1
T-6
X-64
C-11
V-5 (VR-150)
X-20
X-63
C-10
T-9
X-60
C-6
T-5
L-5
X-59
C-7
X-17
V-2
X-61
C-9
L-1
X-16
V-1
X-58
C-5
L-4
X-62
C-8
CABLE W-7
X-25
X-57
C-4
X-19
V-4
L-3
T-2
L-2
X-18
V-5
T-3
T-1
C-1
C-2
C-3
PH-56884

Figure 57—*Bottom Chassis, Front View*

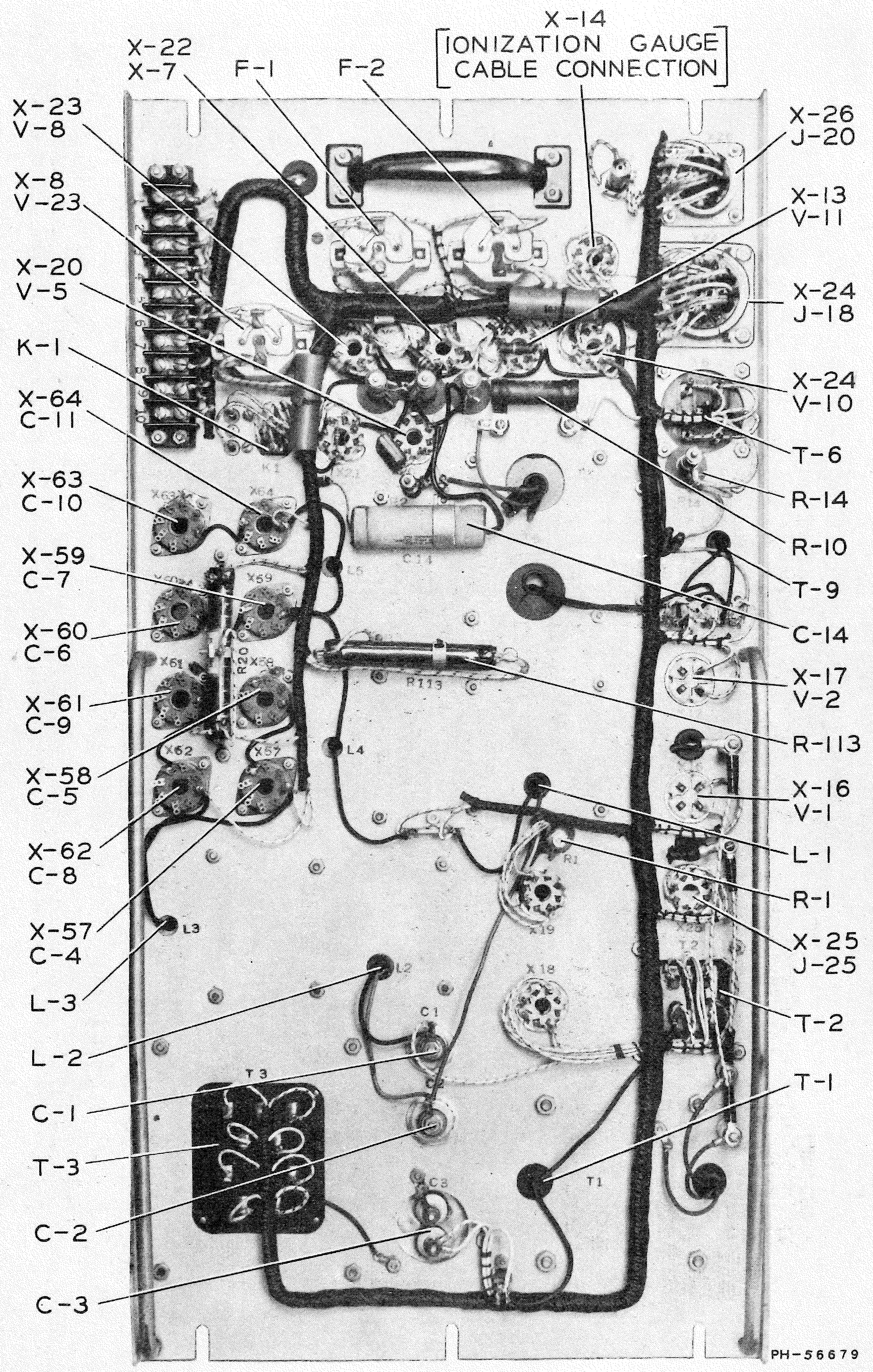

X-22
X-7
F-1
F-2
X-14
IONIZATION GAUGE
CABLE CONNECTION
X-23
V-8
X-26
J-20
X-8
V-23
X-13
V-11
X-20
V-5
X-24
J-18
K-1
X-24
V-10
X-64
C-11
T-6
X-63
C-10
R-14
R-10
X-59
C-7
T-9
X-60
C-6
C-14
X-61
C-9
X-17
V-2
R-113
X-58
C-5
X-16
V-1
X-62
C-8
L-1
R-1
X-57
C-4
X-25
J-25
L-3
T-2
L-2
T-1
C-1
T-3
C-2
C-3
PH-56679

Figure 58—*Bottom Chassis, Rear View*

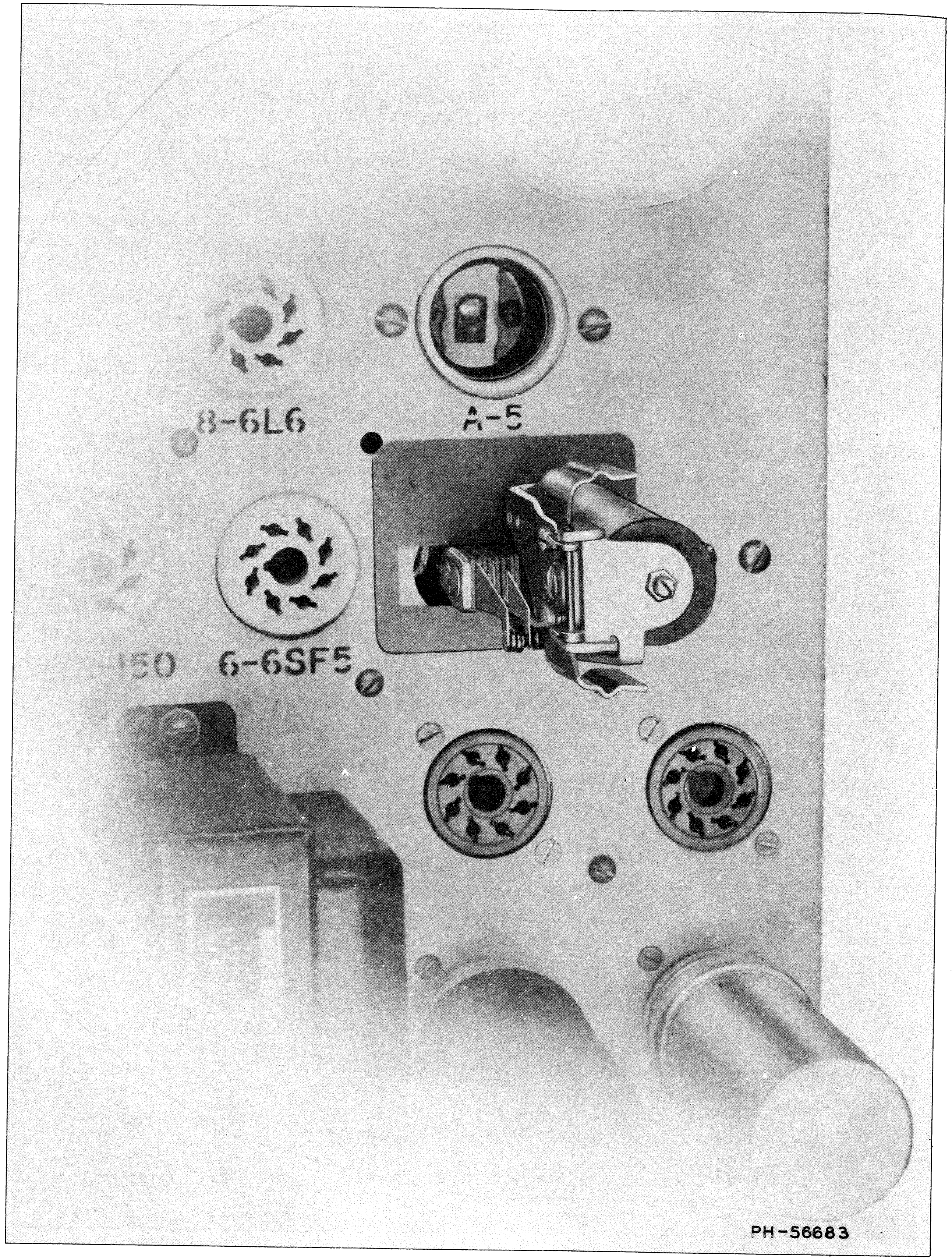

8-6L6
A-5
-150
6-6SF5
PH-56683

Figure 59—Vacuum-Interlock Relay, Close-up View

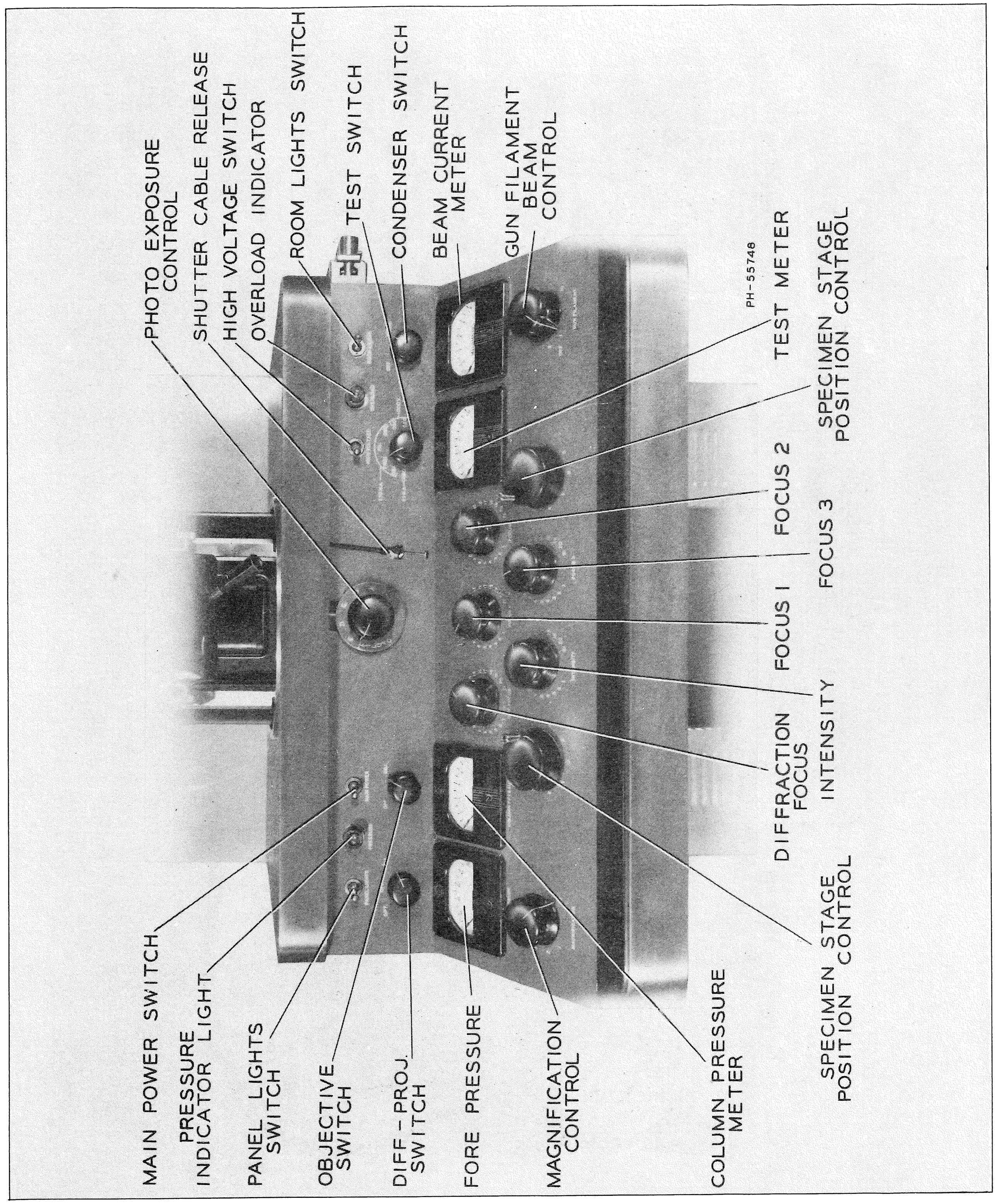


PHOTO EXPOSURE CONTROL
SHUTTER CABLE RELEASE
HIGH VOLTAGE SWITCH
OVERLOAD INDICATOR
ROOM LIGHTS SWITCH
TEST SWITCH
CONDENSER SWITCH
BEAM CURRENT METER
GUN FILAMENT BEAM CONTROL
PH-55748
TEST METER
SPECIMEN STAGE POSITION CONTROL
FOCUS 2
FOCUS 3
FOCUS 1
INTENSITY
DIFFRACTION FOCUS
SPECIMEN STAGE POSITION CONTROL
MAIN POWER SWITCH
PRESSURE INDICATOR LIGHT
PANEL LIGHTS SWITCH
OBJECTIVE SWITCH
DIFF-PROJ SWITCH
FORE PRESSURE
MAGNIFICATION CONTROL
COLUMN PRESSURE METER

Figure 60—Control Panel, Front View

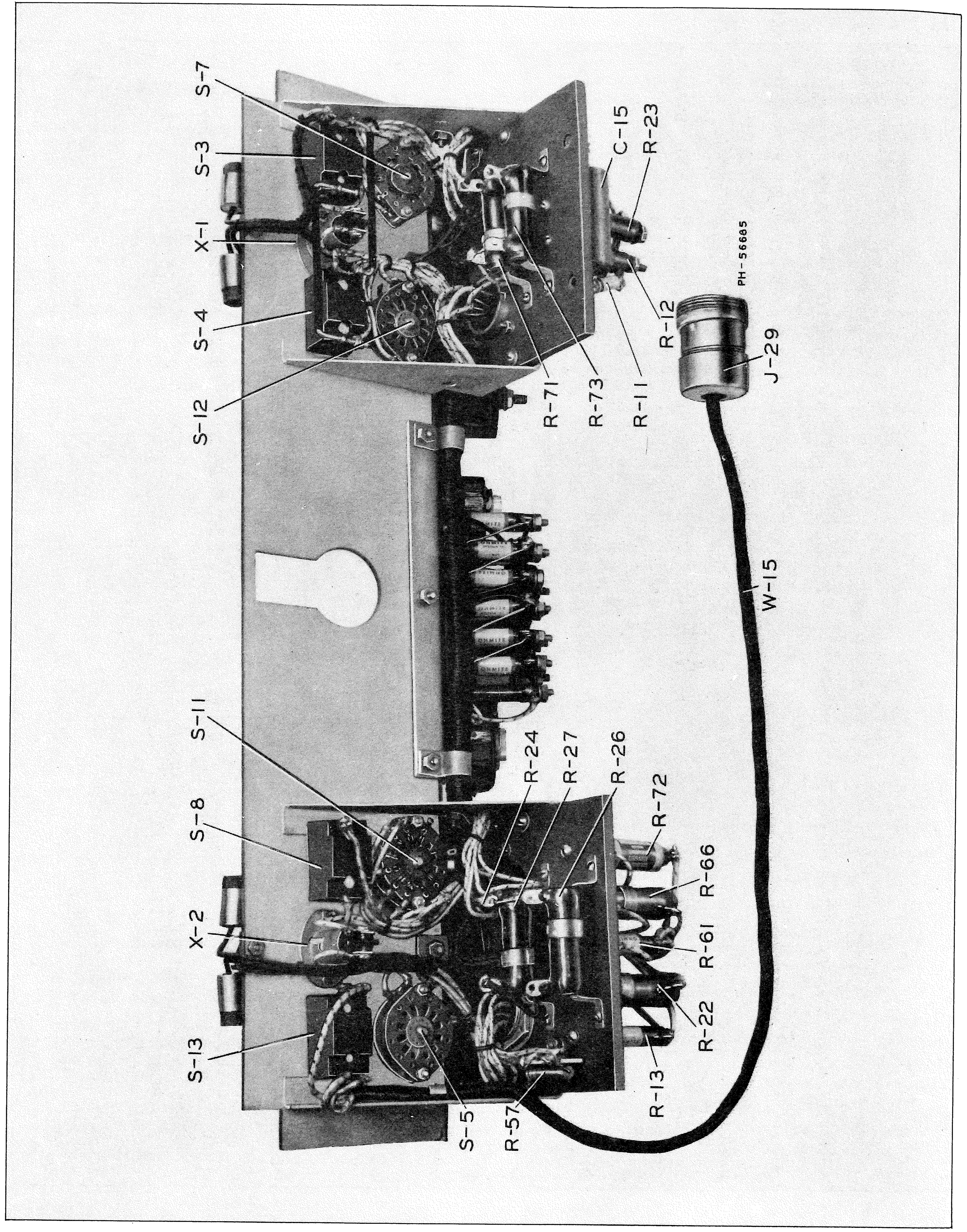

S-7
S-3
X-1
S-4
S-12
C-15
R-23
R-12
R-11
R-73
R-71
J-29
PH-56685
W-15
S-11
S-8
X-2
S-13
S-5
R-57
R-13
R-22
R-61
R-66
R-72
R-26
R-27
R-24

Figure 61—*Control Panel, Rear View*

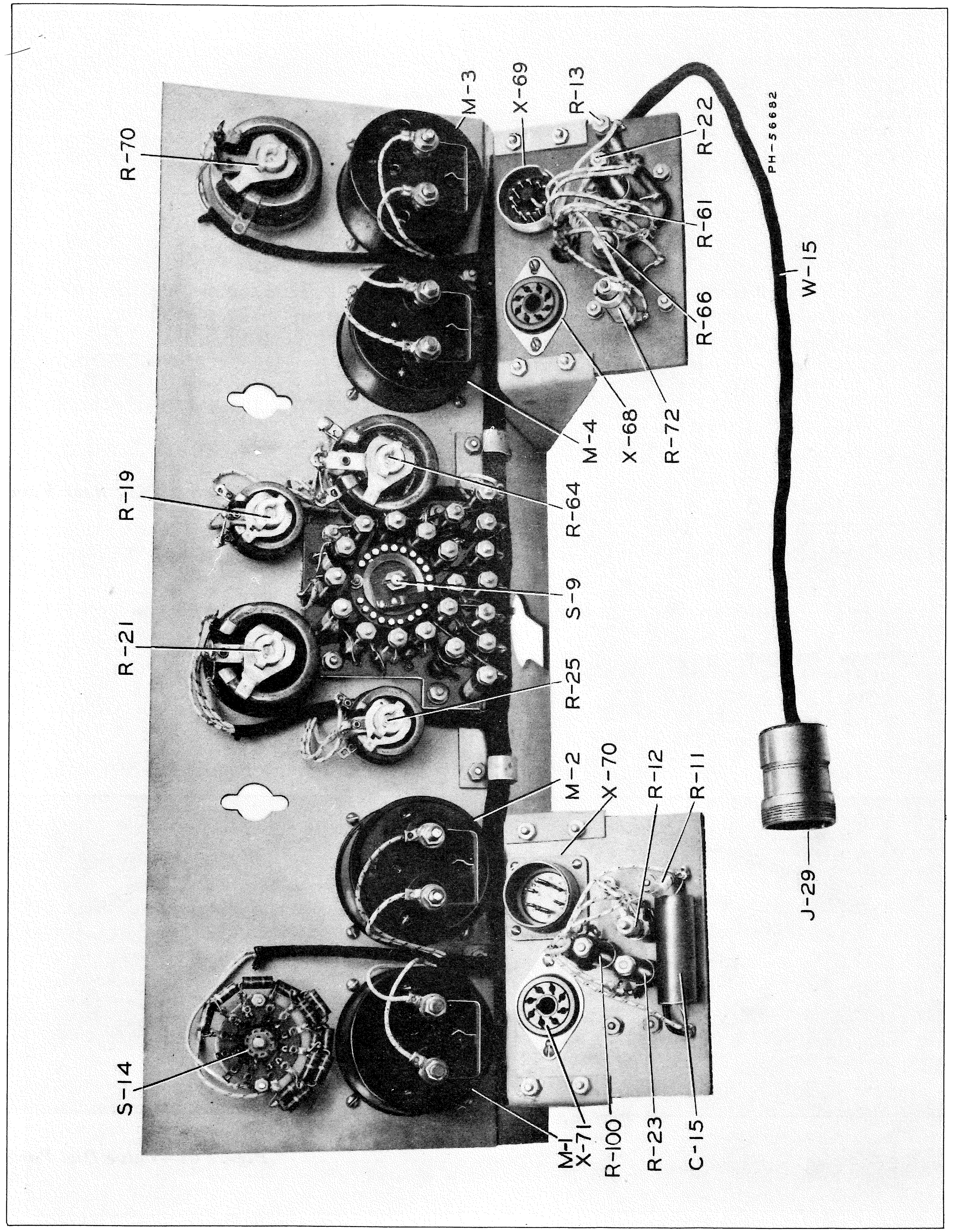

R-70
M-3
X-69
R-13
R-22
PH-56682
R-61
W-15
R-66
R-72
X-68
M-4
R-64
R-19
S-9
R-21
R-25
M-2
X-70
R-12
R-11
J-29
S-14
M-1
X-71
R-100
R-23
C-15

Figure 62—*Control Panel, Bottom View*

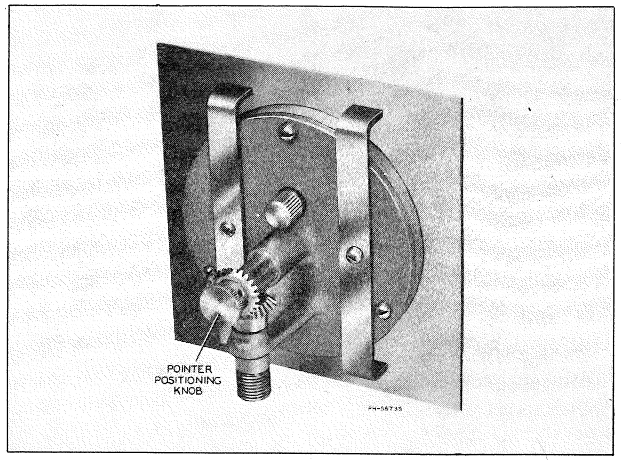

POINTER
POSITIONING
KNOB
PH-56735

Figure 63—Valve Control Dial, Rear View

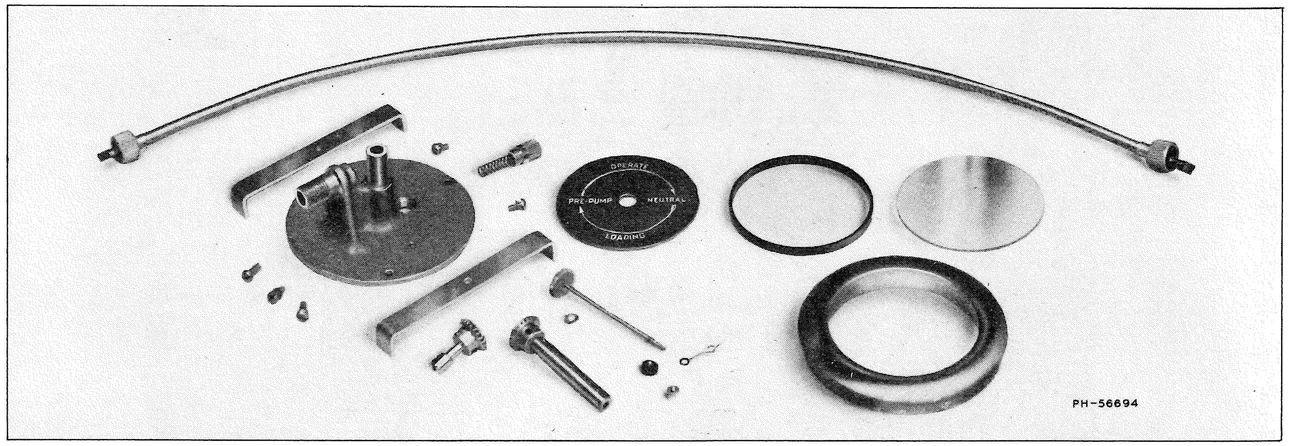

OPERATE
PRE-PUMP
NEUTRAL
PH-56694

Figure 64—Valve Dial Parts

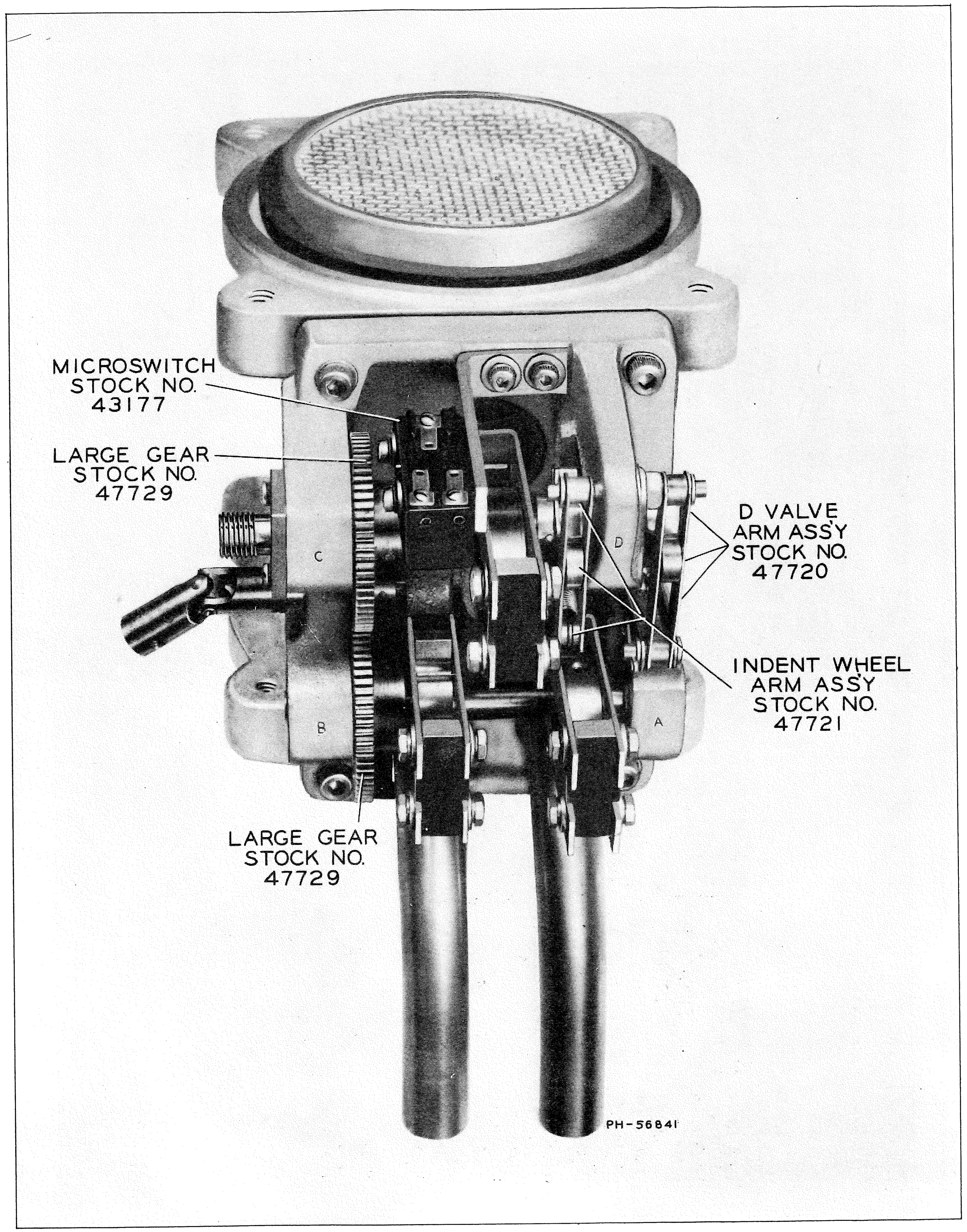

MICROSWITCH
STOCK NO.
43177
LARGE GEAR
STOCK NO.
47729
D VALVE
ARM ASSY
STOCK NO.
47720
INDENT WHEEL
ARM ASSY
STOCK NO.
47721
LARGE GEAR
STOCK NO.
47729
A
B
C
D
PH-56841

Figure 65—Valve Block

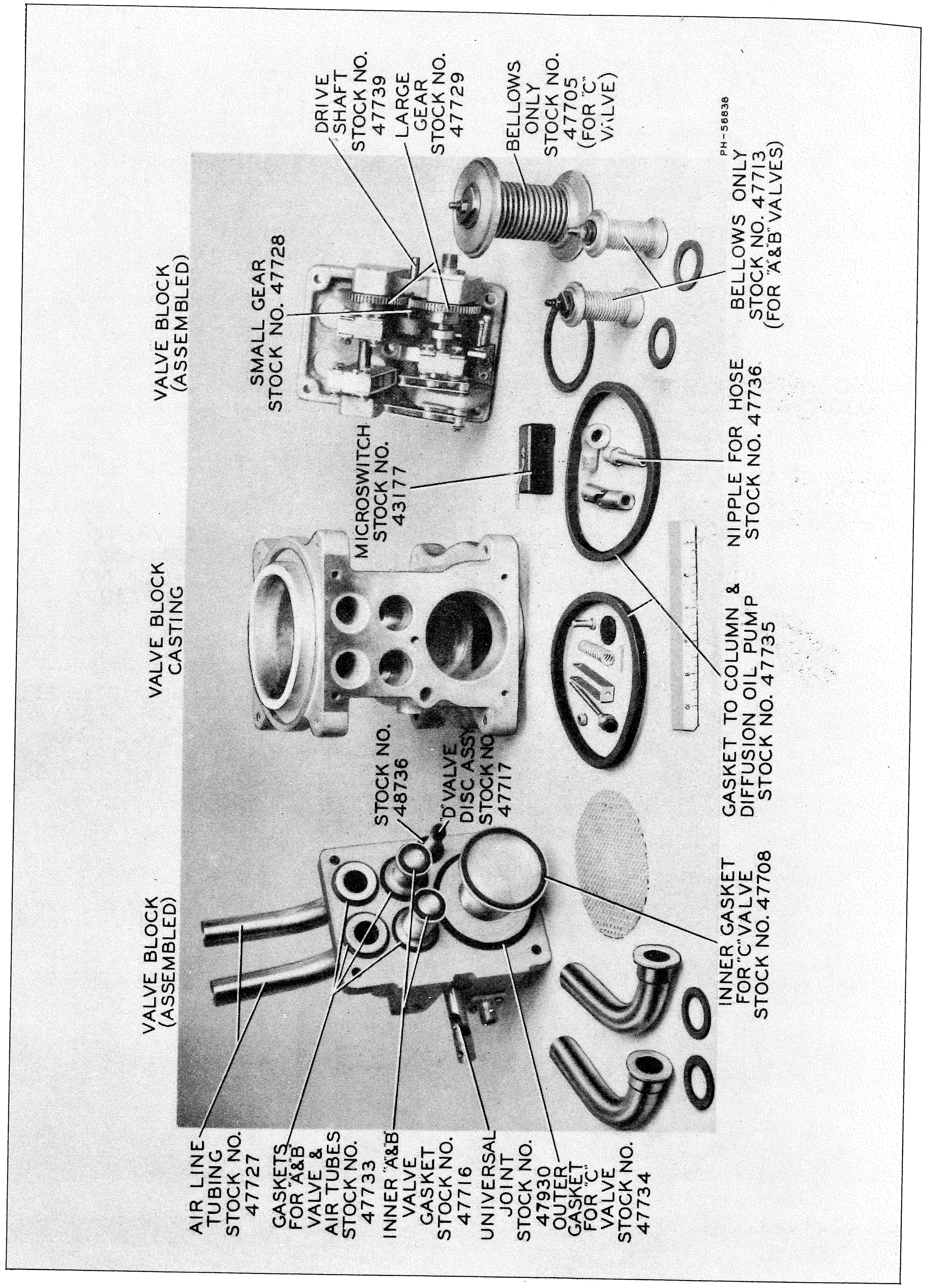

VALVE BLOCK (ASSEMBLED)
VALVE BLOCK CASTING
VALVE BLOCK (ASSEMBLED)
SMALL GEAR STOCK NO. 47728
DRIVE SHAFT STOCK NO. 47739
LARGE GEAR STOCK NO. 47729
BELLOWS ONLY STOCK NO. 47705 (FOR "C" VALVE)
PH-56838
BELLOWS ONLY STOCK NO. 47713 (FOR "A&B" VALVES)
MICROSWITCH STOCK NO. 43177
NIPPLE FOR HOSE STOCK NO. 47736
GASKET TO COLUMN & DIFFUSION OIL PUMP STOCK NO. 47735
STOCK NO. 48736
"D" VALVE DISC ASSY STOCK NO 47717
INNER GASKET FOR "C" VALVE STOCK NO. 47708
AIR LINE TUBING STOCK NO. 47727
GASKETS FOR "A&B" VALVE & AIR TUBES STOCK NO. 47733
INNER "A&B" VALVE GASKET STOCK NO. 47716
UNIVERSAL JOINT STOCK NO. 47930
OUTER GASKET FOR "C" VALVE STOCK NO. 47734

Figure 66—Valve Block Parts

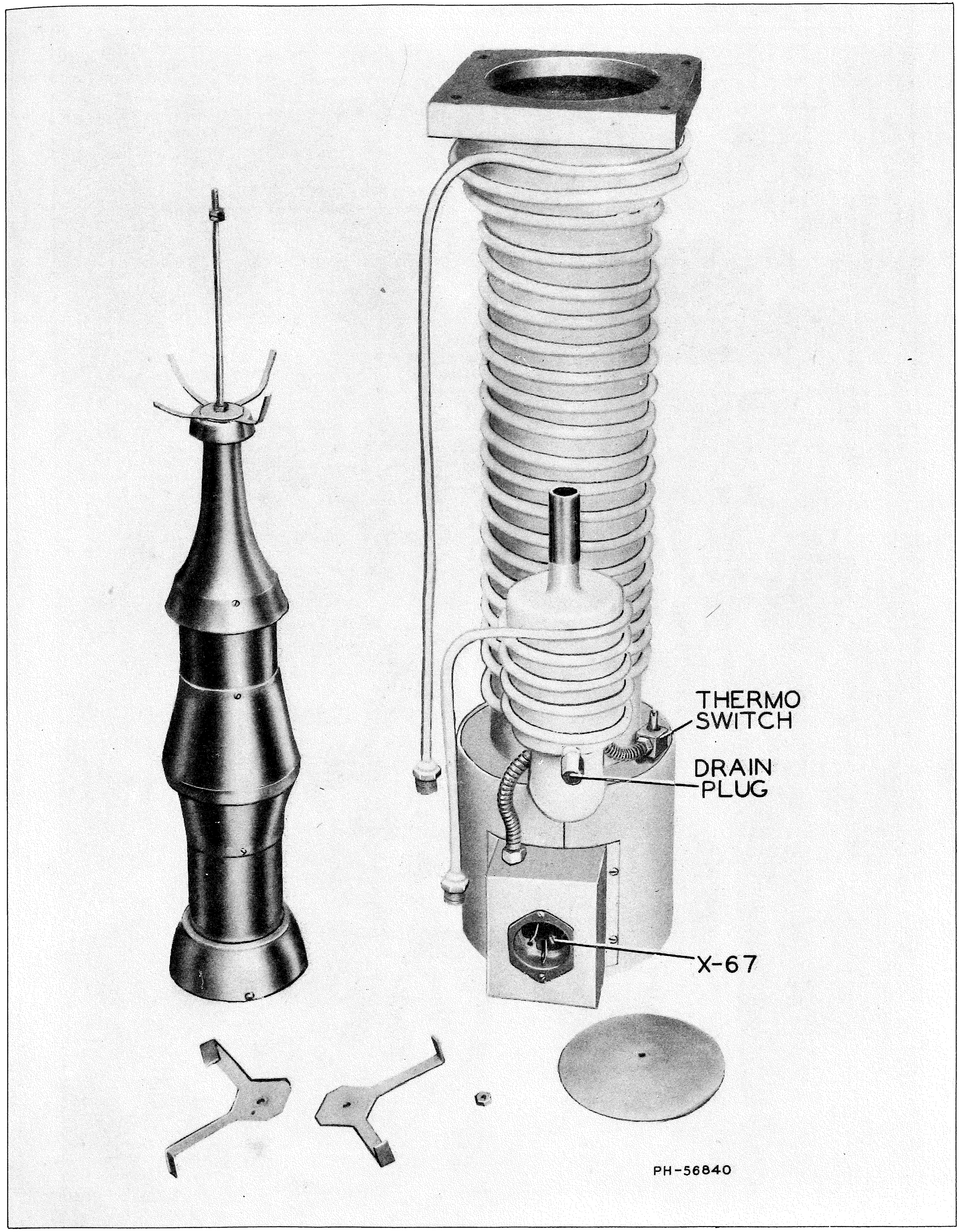

THERMO SWITCH
DRAIN PLUG
X-67
PH-56840

Figure 67—Diffusion Pump, Disassembled

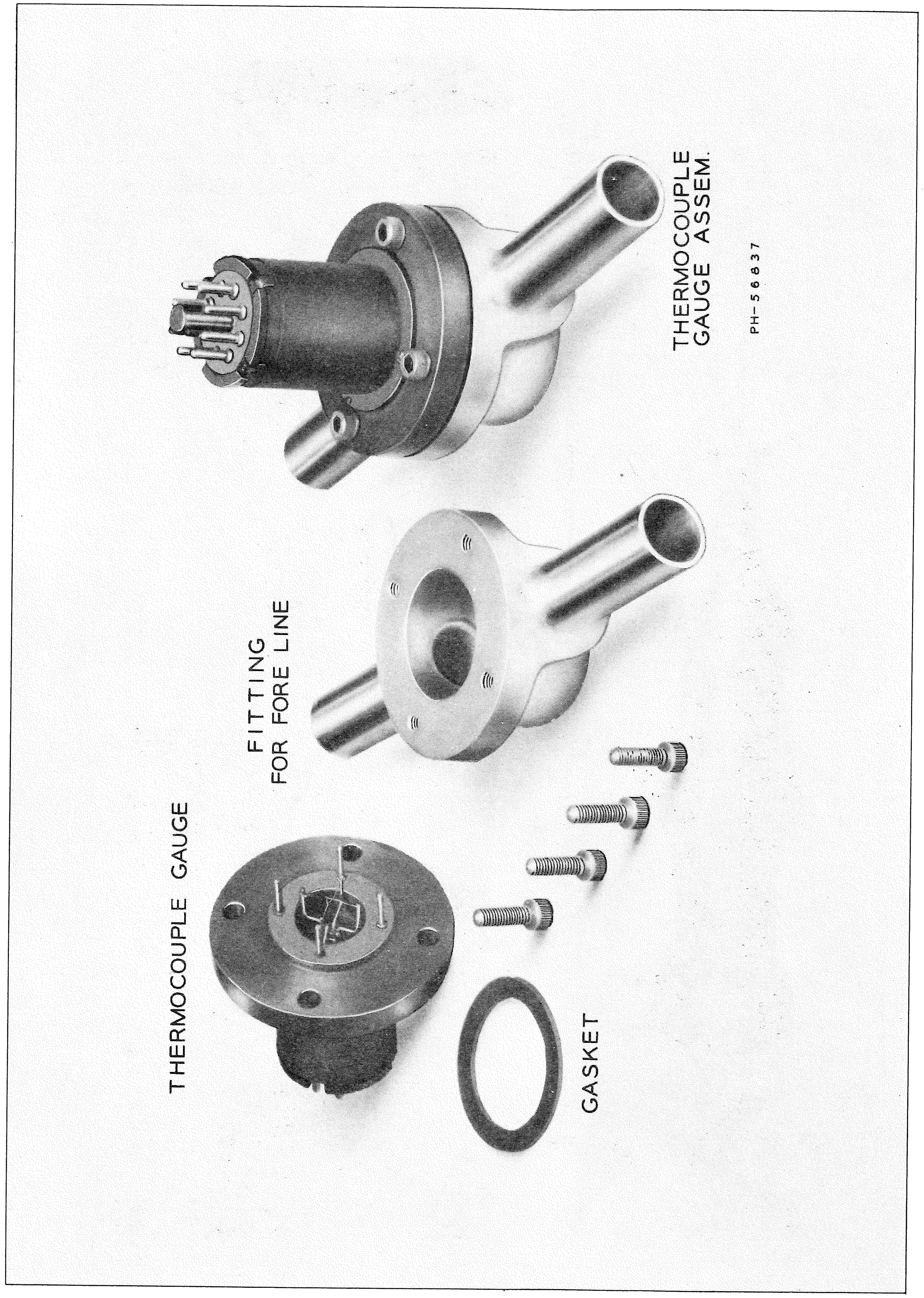

THERMOCOUPLE GAUGE
GASKET
FITTING FOR FORE LINE
THERMOCOUPLE GAUGE ASSEM.
PH-56837

Figure 68—Thermocouple Gauge

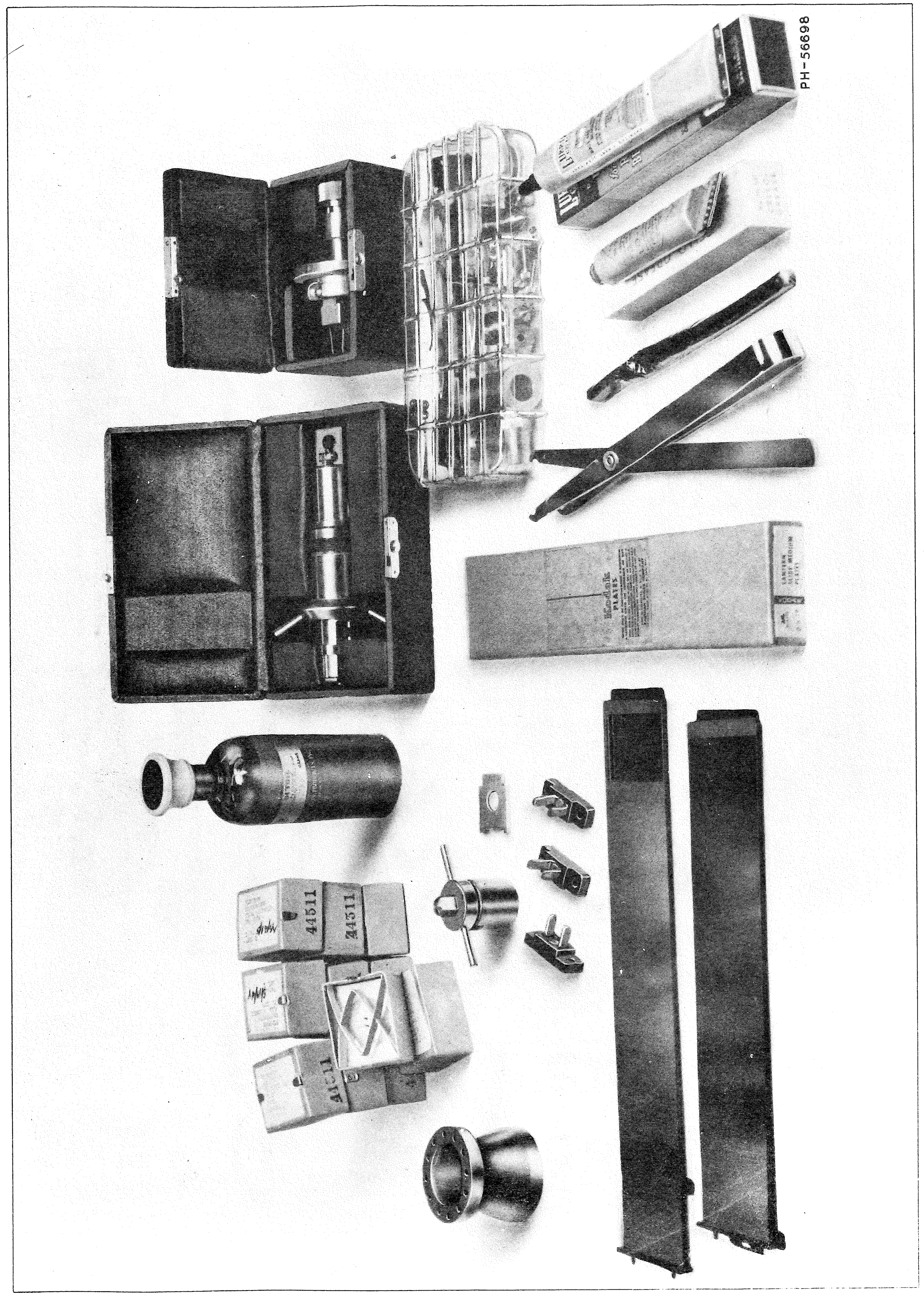

PH-56698
44511
44511
44511

Figure 69—Accessory Kit

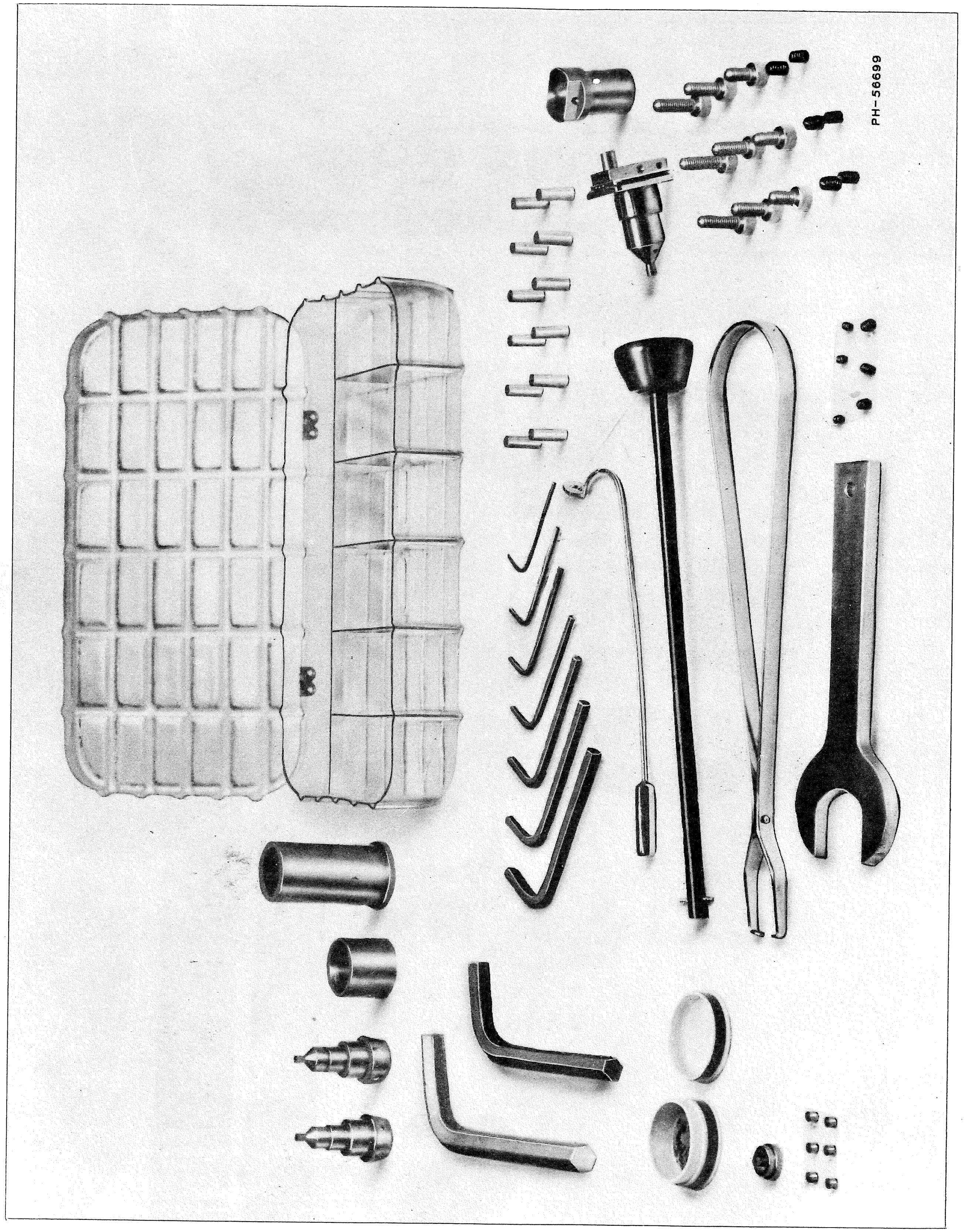


Figure 70—Accessory Kit Contents of Plastic Box

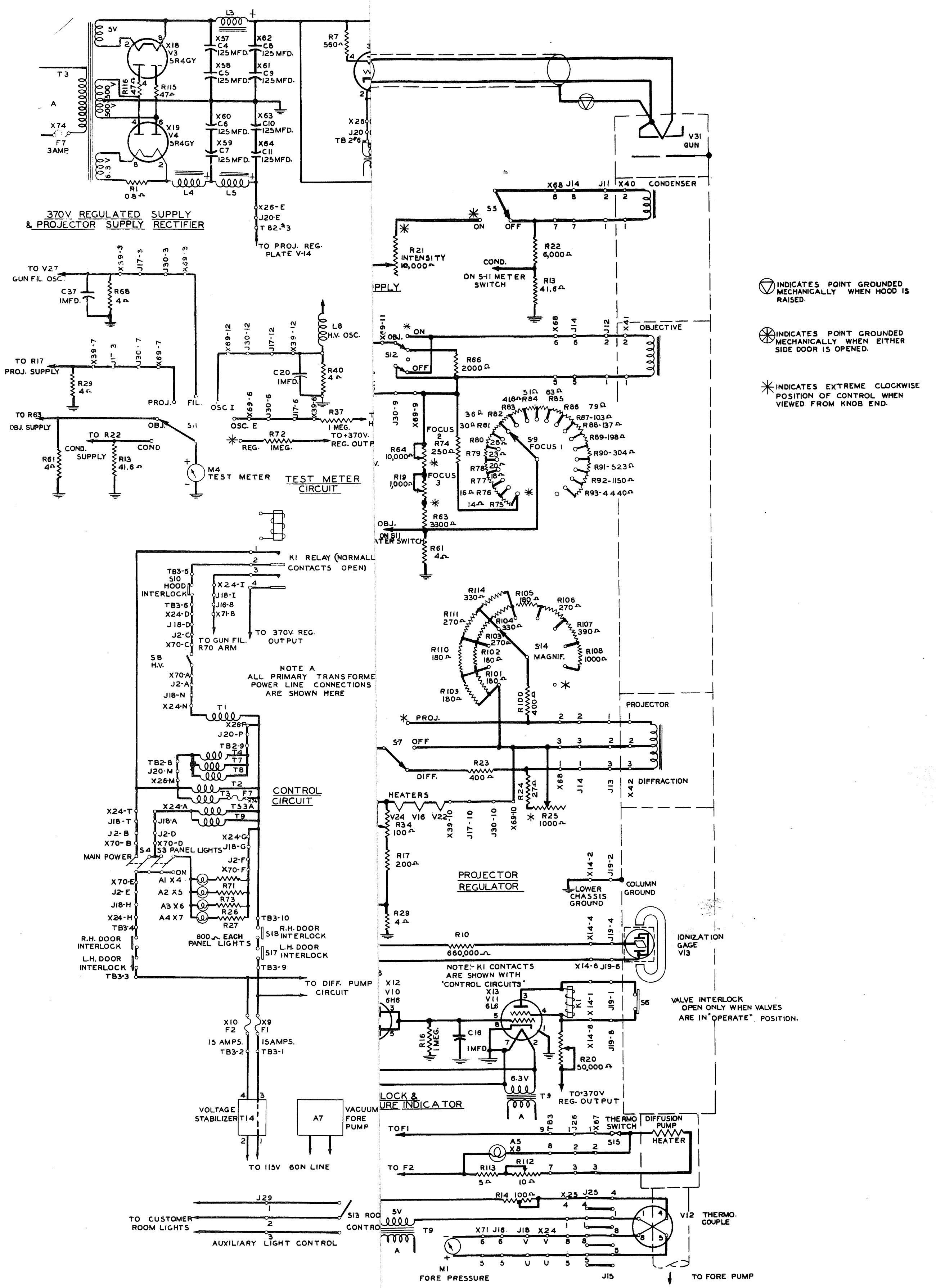
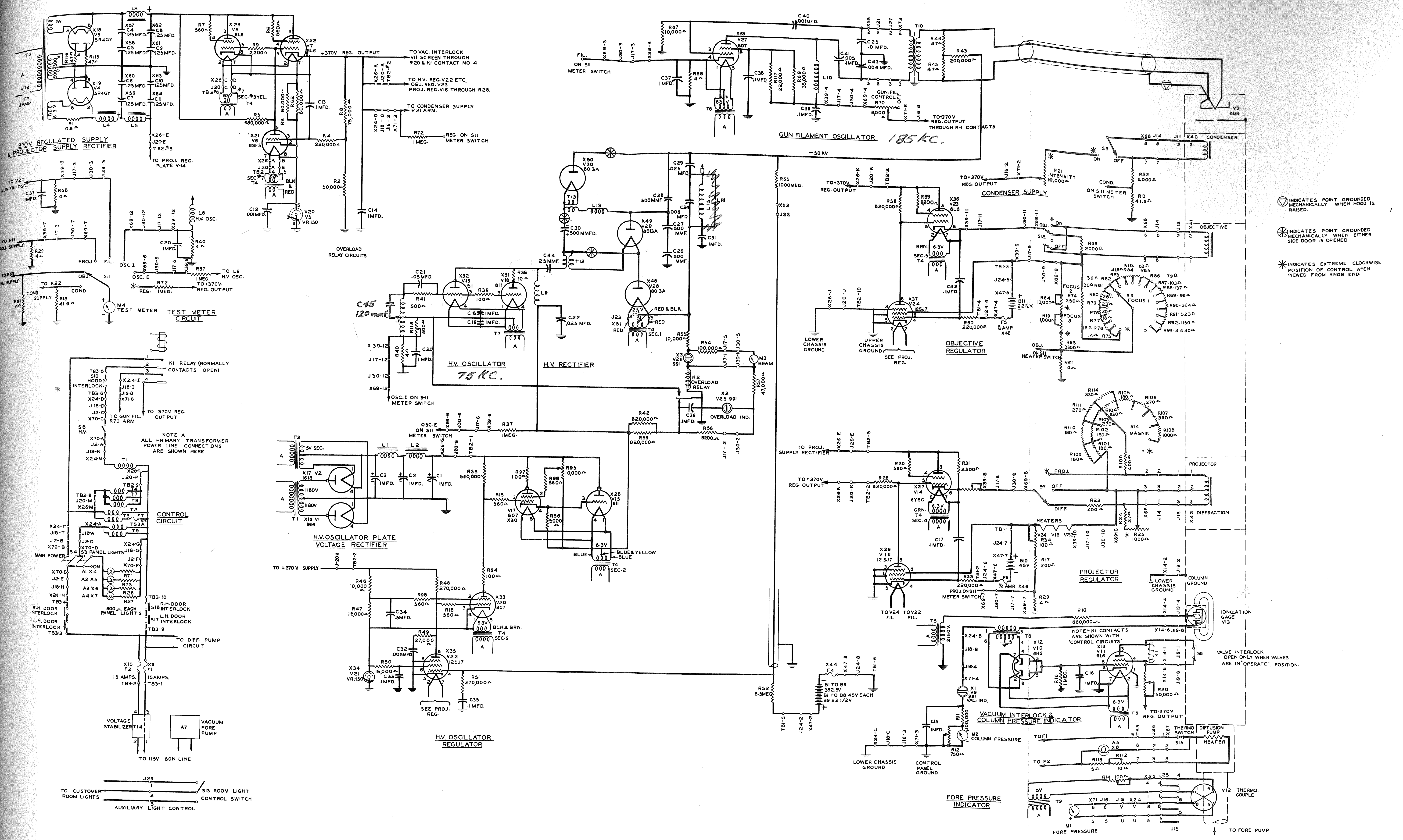

370V REGULATED SUPPLY & PROJECTOR SUPPLY RECTIFIER
TO PROJ. REG. PLATE V-14
TEST METER CIRCUIT
M4 TEST METER
K1 RELAY (NORMALLY CONTACTS OPEN)
TO 370V. REG. OUTPUT
NOTE A ALL PRIMARY TRANSFORMER POWER LINE CONNECTIONS ARE SHOWN HERE
CONTROL CIRCUIT
MAIN POWER
R.H. DOOR INTERLOCK
L.H. DOOR INTERLOCK
800 EACH PANEL LIGHTS
TO DIFF. PUMP CIRCUIT
15 AMPS.
VOLTAGE STABILIZER T14
A7 VACUUM FORE PUMP
TO 115V 60N LINE
TO CUSTOMER ROOM LIGHTS
AUXILIARY LIGHT CONTROL
V31 GUN
CONDENSER
R21 INTENSITY 10,000
ON S-11 METER SWITCH
OBJECTIVE
FOCUS
S14 MAGNIF.
PROJECTOR
DIFFRACTION
HEATERS
PROJECTOR REGULATOR
LOWER CHASSIS GROUND
COLUMN GROUND
IONIZATION GAGE V13
NOTE: K1 CONTACTS ARE SHOWN WITH "CONTROL CIRCUITS"
VALVE INTERLOCK OPEN ONLY WHEN VALVES ARE IN "OPERATE" POSITION.
THERMO SWITCH
DIFFUSION PUMP HEATER
V12 THERMO. COUPLE
M1 FORE PRESSURE
TO FORE PUMP
INDICATES POINT GROUNDED MECHANICALLY WHEN HOOD IS RAISED.
INDICATES POINT GROUNDED MECHANICALLY WHEN EITHER SIDE DOOR IS OPENED.
INDICATES EXTREME CLOCKWISE POSITION OF CONTROL WHEN VIEWED FROM KNOB END.

Figure 71—Electron Microscope Type EMU-1, Circuit Schematic Diagram (W-302952)


370V REGULATED SUPPLY & PROJECTOR SUPPLY RECTIFIER
TO VAC. INTERLOCK V11 SCREEN THROUGH R20 & K1 CONTACT NO. 4
TO H.V. REG. V22 ETC. OBJ. REG. V23 PROJ. REG. V16 THROUGH R28.
TO CONDENSER SUPPLY R21 ARM.
REG. ON S11 METER SWITCH
+370V REG. OUTPUT
OVERLOAD RELAY CIRCUITS
TEST METER CIRCUIT
M4 TEST METER
GUN FILAMENT OSCILLATOR
185 kc.
-50 KV
H.V. OSCILLATOR
75 kc.
C45 120 mmf
H.V. RECTIFIER
OVERLOAD IND.
K2 OVERLOAD RELAY
M3 BEAM
CONDENSER SUPPLY
OBJECTIVE REGULATOR
FOCUS
PROJECTOR REGULATOR
MAGNIF.
CONDENSER
OBJECTIVE
PROJECTOR
DIFFRACTION
V31 GUN
K1 RELAY (NORMALLY CONTACTS OPEN)
NOTE A ALL PRIMARY TRANSFORMER POWER LINE CONNECTIONS ARE SHOWN HERE
CONTROL CIRCUIT
MAIN POWER
PANEL LIGHTS
TO DIFF. PUMP CIRCUIT
VOLTAGE STABILIZER
VACUUM FORE PUMP
TO 115V 60N LINE
TO CUSTOMER ROOM LIGHTS
S13 ROOM LIGHT CONTROL SWITCH
AUXILIARY LIGHT CONTROL
H.V. OSCILLATOR PLATE VOLTAGE RECTIFIER
H.V. OSCILLATOR REGULATOR
LOWER CHASSIS GROUND
UPPER CHASSIS GROUND
IONIZATION GAGE V13
VALVE INTERLOCK OPEN ONLY WHEN VALVES ARE IN "OPERATE" POSITION.
NOTE:- K1 CONTACTS ARE SHOWN WITH "CONTROL CIRCUITS"
VACUUM INTERLOCK & COLUMN PRESSURE INDICATOR
M2 COLUMN PRESSURE
FORE PRESSURE INDICATOR
M1 FORE PRESSURE
V12 THERMO. COUPLE
DIFFUSION PUMP HEATER
TO FORE PUMP

INDICATES POINT GROUNDED MECHANICALLY WHEN HOOD IS RAISED.

INDICATES POINT GROUNDED MECHANICALLY WHEN EITHER SIDE DOOR IS OPENED.

✳ INDICATES EXTREME CLOCKWISE POSITION OF CONTROL WHEN VIEWED FROM KNOB END.

Figure 71—Electron Microscope Type EMU-1, Circuit Schematic Diagram (W-302952)

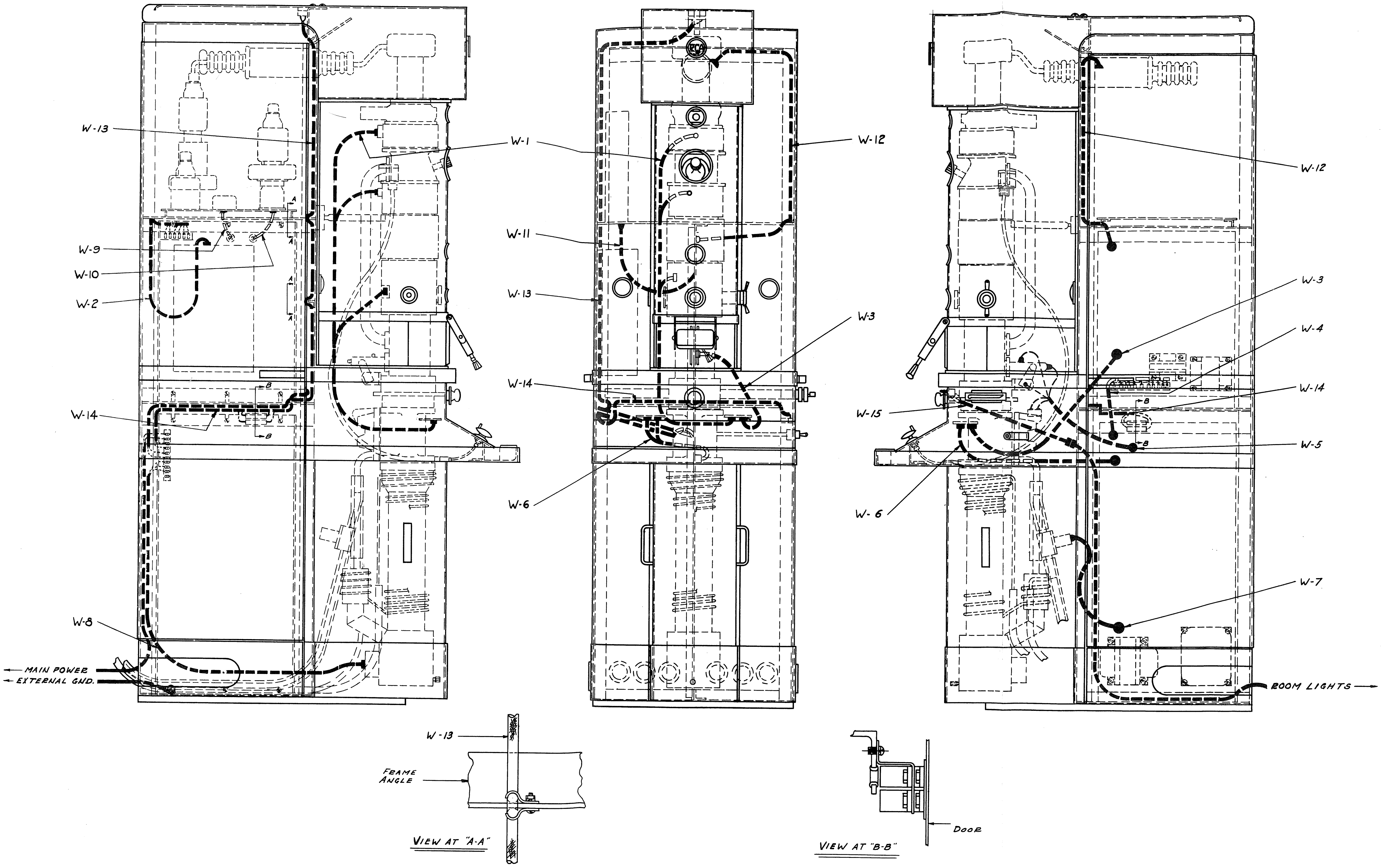

W-13
W-1
W-12
W-9
W-10
W-2
W-14
W-8
← MAIN POWER
← EXTERNAL GND.
W-11
W-13
W-14
W-3
W-6
W-12
W-3
W-4
W-14
W-15
W-5
W-6
W-7
ROOM LIGHTS →
W-13
FRAME ANGLE
VIEW AT "A-A"
DOOR
VIEW AT "B-B"

Figure 72—Cabinet Wiring Diagram
(W-302972—Sub. 0)

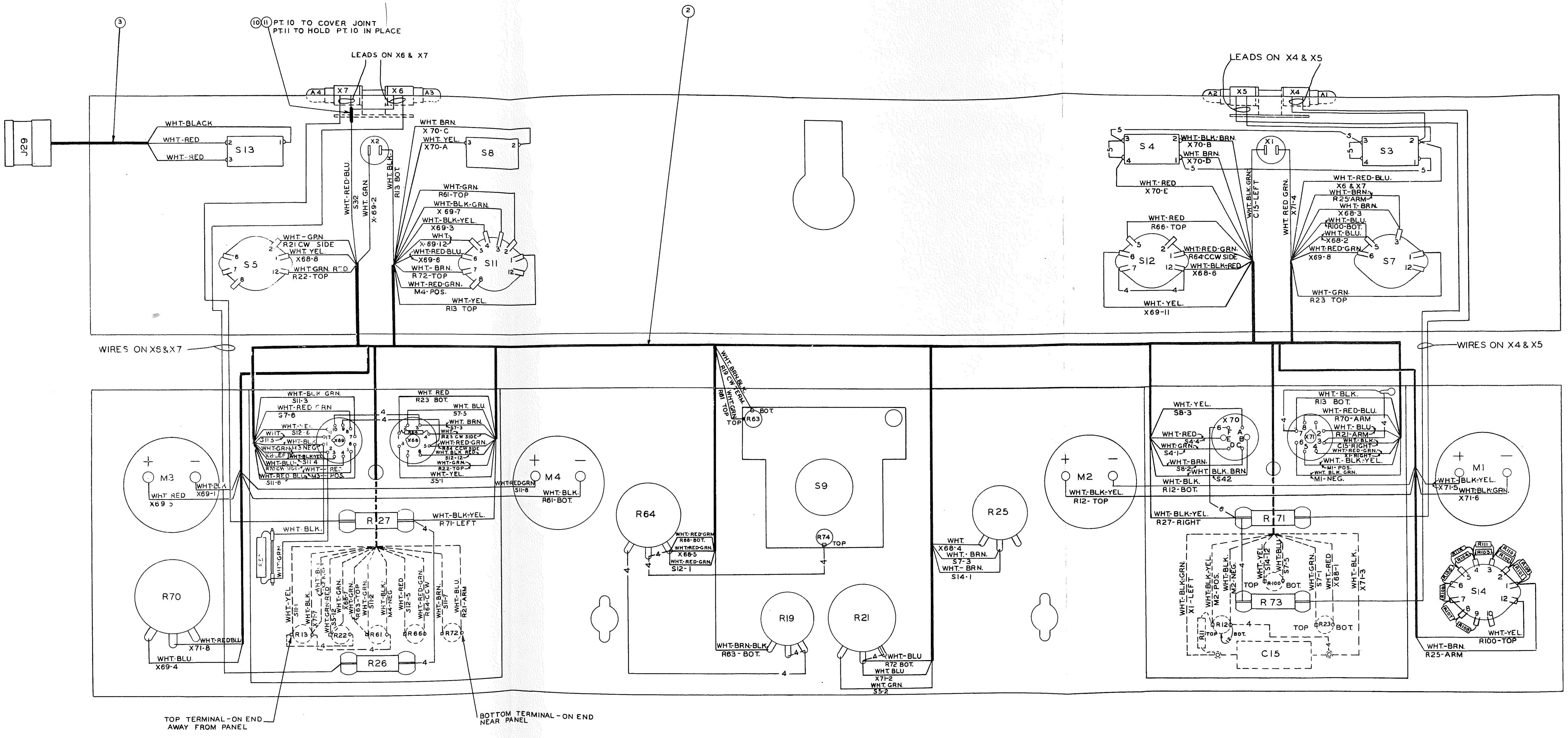

③
⑩⑪ PT. 10 TO COVER JOINT
PT. 11 TO HOLD PT. 10 IN PLACE
LEADS ON X6 & X7
②
LEADS ON X4 & X5
J29
S13
S8
S5
S11
S4
S3
S12
S7
X1
X2
A1
A2
A3
A4
X4
X5
X6
X7
WIRES ON X6 & X7
WIRES ON X4 & X5
M3
M4
M2
M1
R27
R26
R70
R64
R19
R21
S9
R25
R71
R73
C15
S14
X68
X69
X70
X71
TOP TERMINAL - ON END AWAY FROM PANEL
BOTTOM TERMINAL - ON END NEAR PANEL

Figure 73—Connection Diagram, Control Panel
(W-302959—Sub. 1)

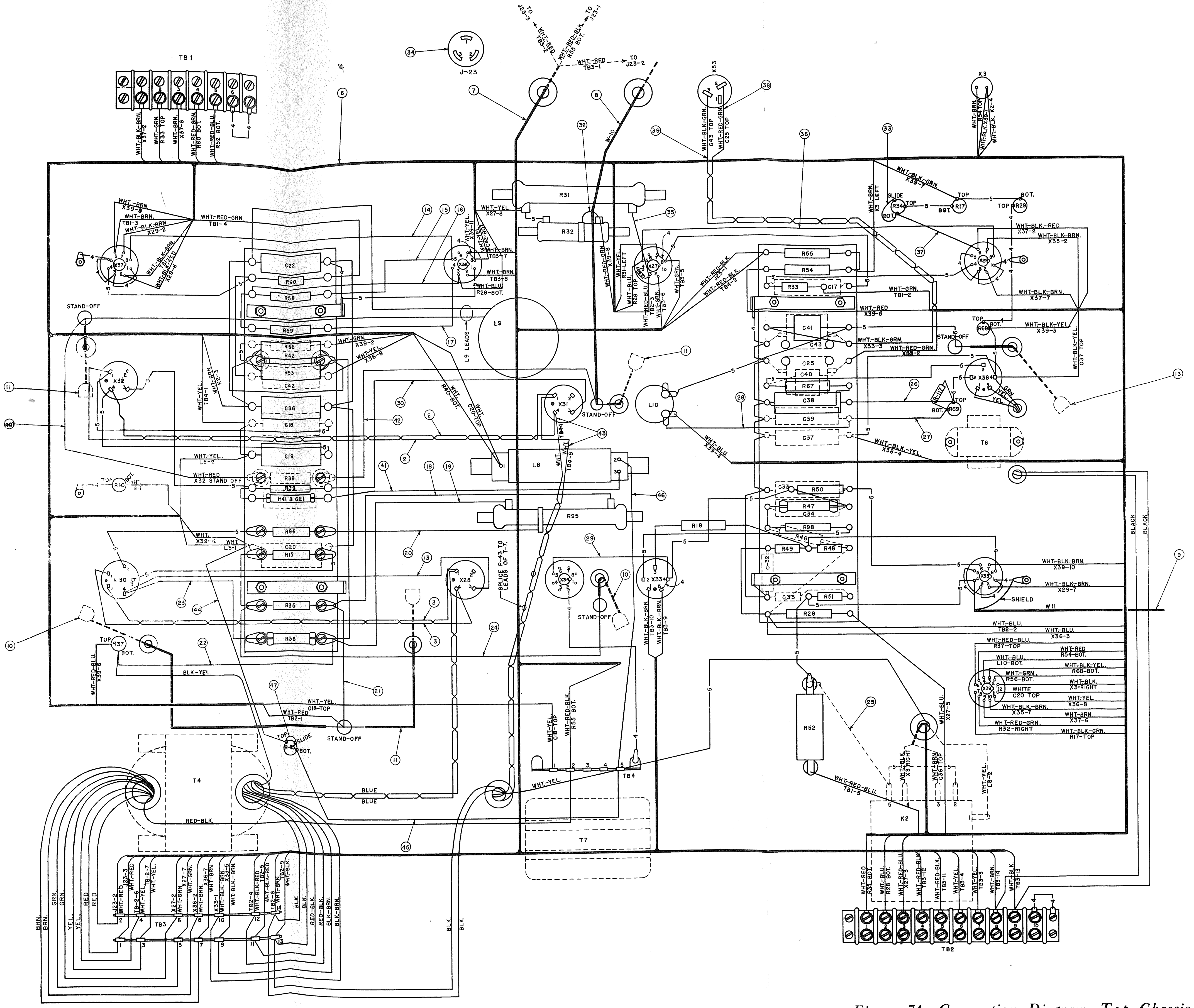

TB 1
J-23
X53
X3
T4
T7
T8
TB2
TB3
TB4
K2
L8
L9
L10
R31
R32
R95
R52
C22
R60
R58
R59
R56
R42
R53
C42
C36
C18
C19
R38
R39
R41 & C21
R96
C20
R15
R35
R36
R55
R54
R33
C17
C41
C43
C25
C40
R67
C38
C39
C37
R50
R47
C34
R98
R49
R48
R51
C35
R28
R18
X27
X28
X29
X30
X31
X32
X33
X34
X35
X36
X37
X38
X39
STAND-OFF
SHIELD
W11
W-10
BLUE
BLK.
BLACK
RED-BLK.
BLK-YEL
SPLICE P-43 TO LEADS OF T-7.
L9 LEADS
TO J23-2
TO J23-1
TO J23-3

Figure 74—Connection Diagram, Top Chassis
(W-302955—Sub. 3)

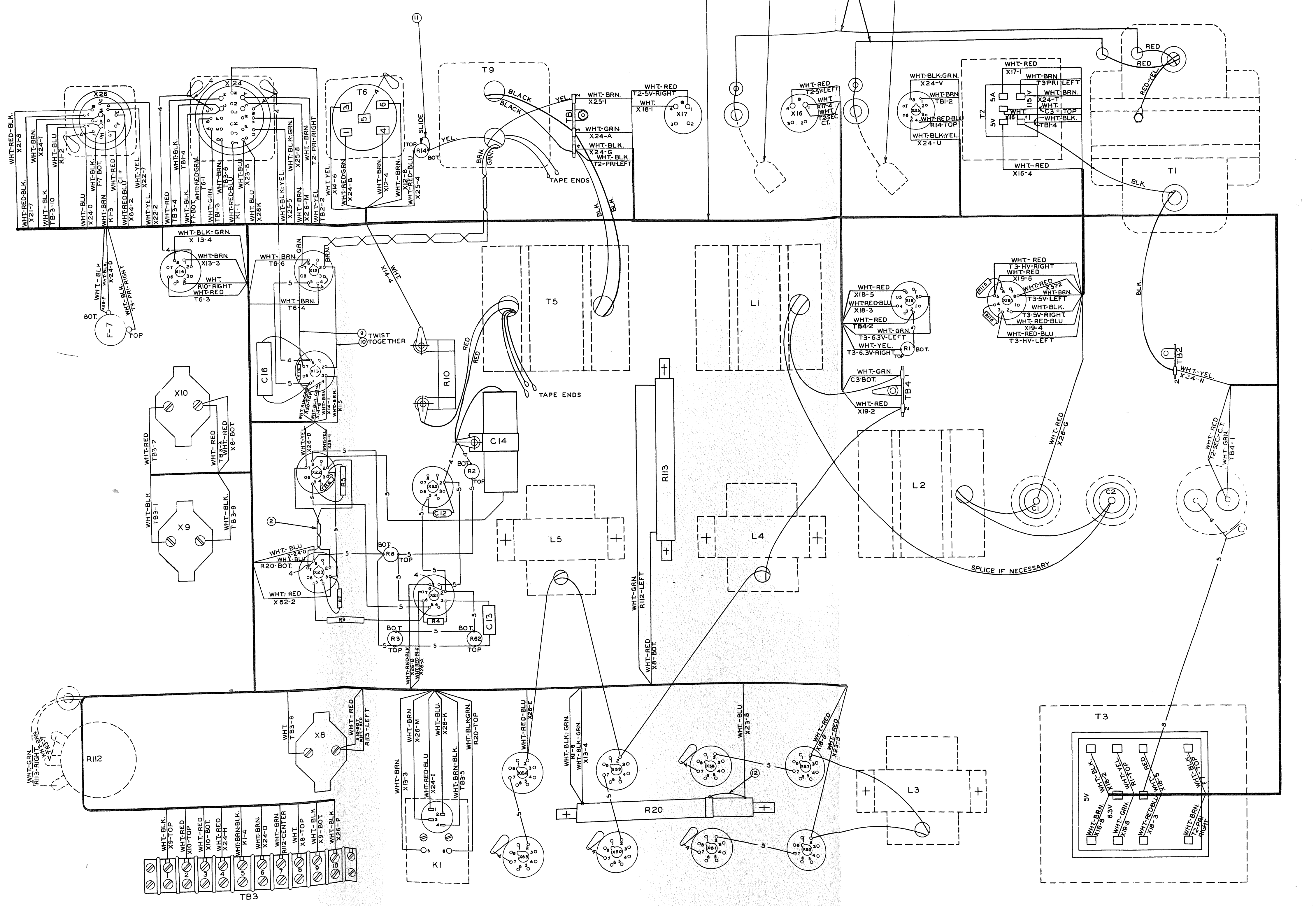

X26
X24
T6
T9
TB1
R14
SLIDE
TOP
BOT.
BLACK
YEL.
BRN.
GRN.
TAPE ENDS
X25-1
X17
X16
X23
T2
5A
5V
115V
T1
RED
RED-YEL.
BLK.
X14
F-7
X10
X9
C16
X13
X12
TWIST TOGETHER
R10
T5
L1
TB4
R1
X19
X18
C14
R2
X22
R5
X20
C12
R113
L5
L4
L2
C1
C2
SPLICE IF NECESSARY
TB2
X23
R8
X21
R4
R9
R3
R62
C13
X8
R112
K1
TB3
X64
X59
X58
X60
X65
X61
X57
X62
R20
L3
T3
6.3V
WHT-RED
WHT-BRN.
WHT-BLK.
WHT-GRN.
WHT-YEL.
WHT-BLU
WHT-RED-BLU
WHT-BLK-GRN.
WHT-BRN-BLK.
2
3
6
7
9
10
11
12

Figure 75—Connection Diagram, Bottom Chassis (W-302957—Sub. 1)

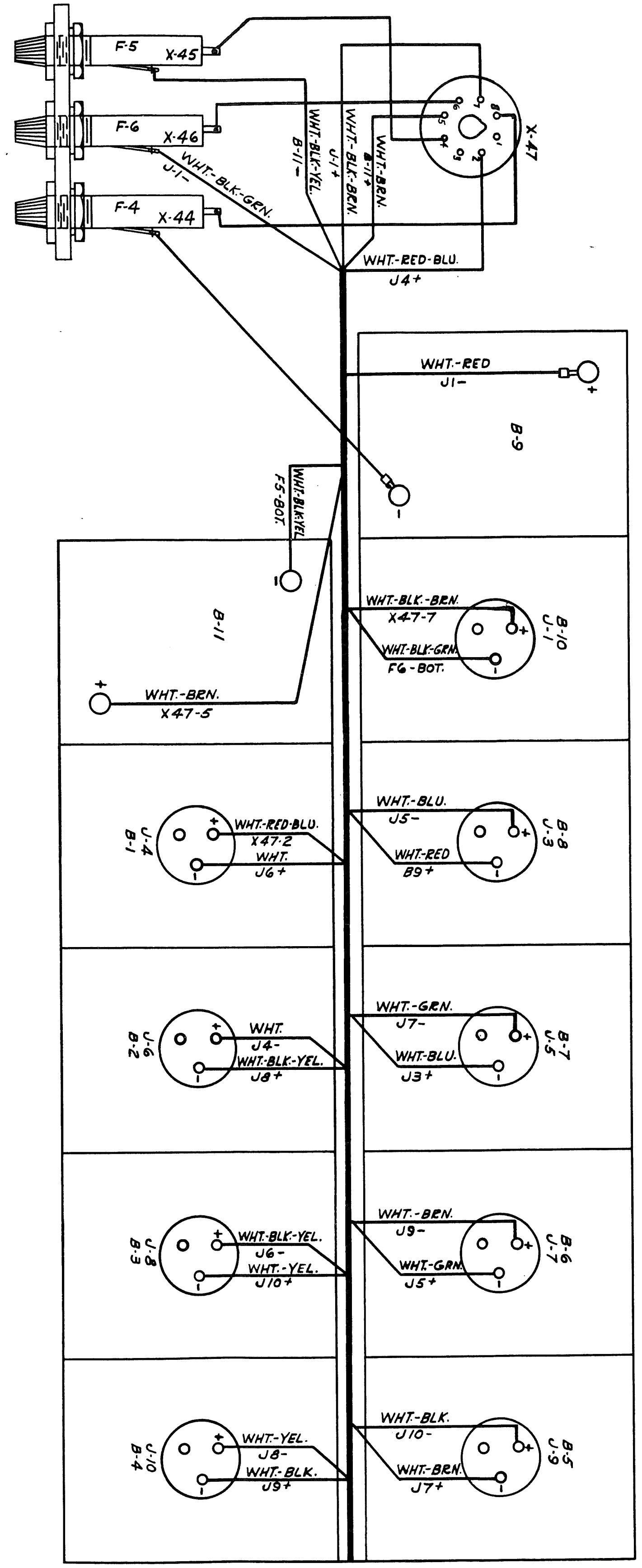

F-5
X-45
F-6
X-46
F-4
X-44
X-47
WHT.-BLK.-GRN.
J-1 −
WHT.-BLK.-YEL.
B-11 −
WHT.-BLK.-BRN.
J-1 +
WHT.-BRN.
B-11 +
WHT.-RED-BLU.
J4 +
WHT.-RED
J1 −
B-9
WHT.-BLK.-YEL.
F5-BOT.
B-11
WHT.-BRN.
X47-5
WHT.-BLK.-BRN.
X47-7
WHT.-BLK.-GRN.
F6-BOT.
B-10
J-1
J-4
B-1
WHT.-RED-BLU.
X47-2
WHT.
J6 +
WHT.-BLU.
J5 −
WHT.-RED
B9 +
B-8
J-3
J-6
B-2
WHT.
J4 −
WHT.-BLK.-YEL.
J8 +
WHT.-GRN.
J7 −
WHT.-BLU.
J3 +
B-7
J-5
J-8
B-3
WHT.-BLK.-YEL.
J6 −
WHT.-YEL.
J10 +
WHT.-BRN.
J9 −
WHT.-GRN.
J5 +
B-6
J-7
J-10
B-4
WHT.-YEL.
J8 −
WHT.-BLK.
J9 +
WHT.-BLK.
J10 −
WHT.-BRN.
J7 +
B-5
J-9

Figure 76—Connection Diagram, Battery Box
(P-719138—Sub. 0)

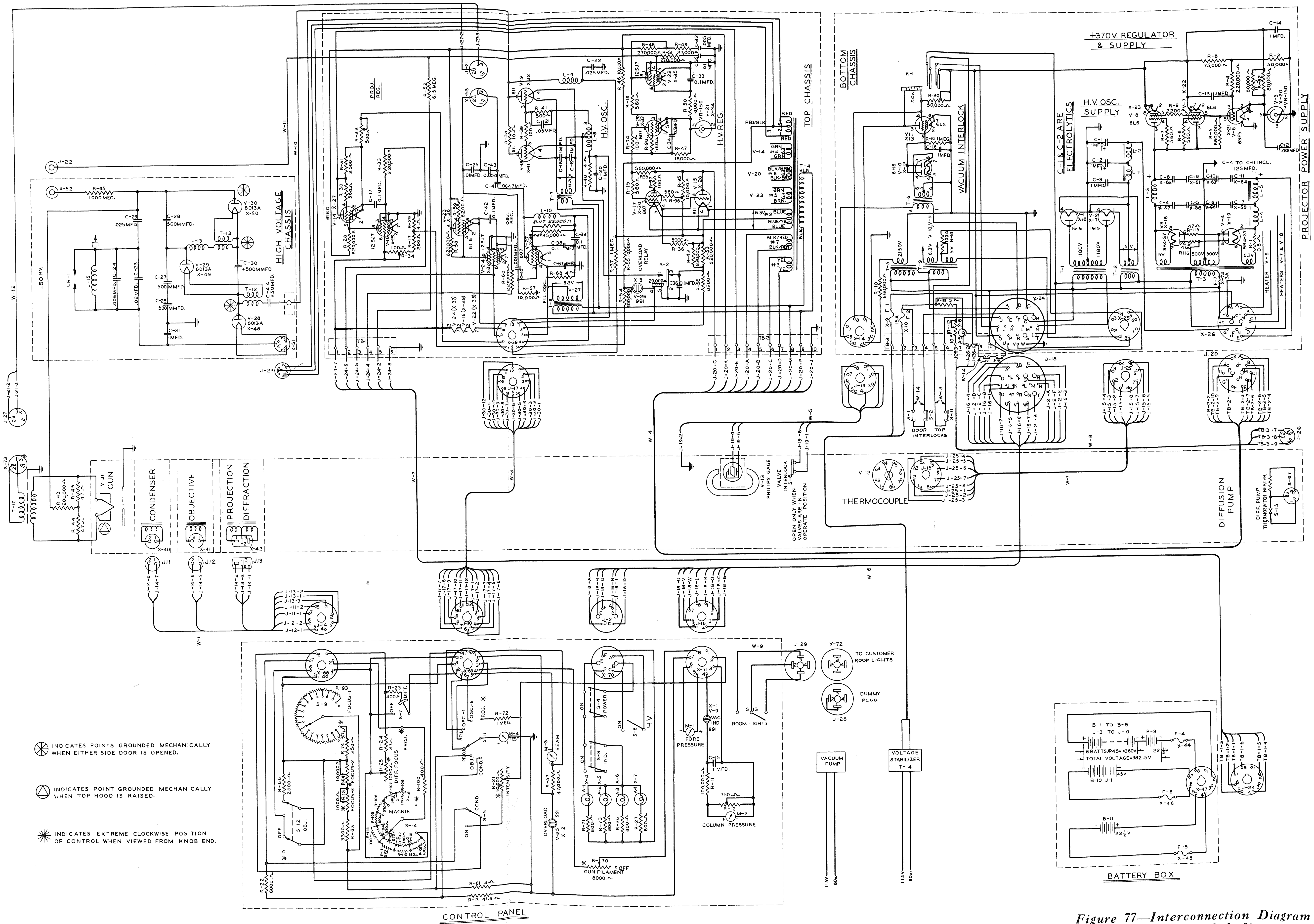

HIGH VOLTAGE CHASSIS
-50 KV.
PROJ. REG.
H.V. OSC.
H.V. REG.
TOP CHASSIS
BOTTOM CHASSIS
VACUUM INTERLOCK
C-1 & C-2 ARE ELECTROLYTICS
H.V. OSC. SUPPLY
+370V. REGULATOR & SUPPLY
PROJECTOR POWER SUPPLY
GUN
CONDENSER
OBJECTIVE
PROJECTION
DIFFRACTION
DOOR TOP INTERLOCKS
V-13 PHILIPS GAGE
VALVE INTERLOCK
OPEN ONLY WHEN VALVES ARE IN OPERATE POSITION
THERMOCOUPLE
DIFFUSION PUMP
DIFF. PUMP THERMOSWITCH HEATER
TO CUSTOMER ROOM LIGHTS
DUMMY PLUG
ROOM LIGHTS
FORE PRESSURE
COLUMN PRESSURE
VACUUM PUMP
VOLTAGE STABILIZER T-14
115V 60~
CONTROL PANEL
FOCUS-1
FOCUS-2
DIFF. FOCUS
MAGNIF.
PROJ.
OBJ.
COND.
INTENSITY
BEAM
OVERLOAD
GUN FILAMENT
POWER
HV
BATTERY BOX
B-1 TO B-8
J-3 TO J-10
8 BATTS.@45V=360V
TOTAL VOLTAGE=382.5V
22½V
INDICATES POINTS GROUNDED MECHANICALLY WHEN EITHER SIDE DOOR IS OPENED.
INDICATES POINT GROUNDED MECHANICALLY WHEN TOP HOOD IS RAISED.
INDICATES EXTREME CLOCKWISE POSITION OF CONTROL WHEN VIEWED FROM KNOB END.

Figure 77—Interconnection Diagram
(W-302973—Sub. 0)

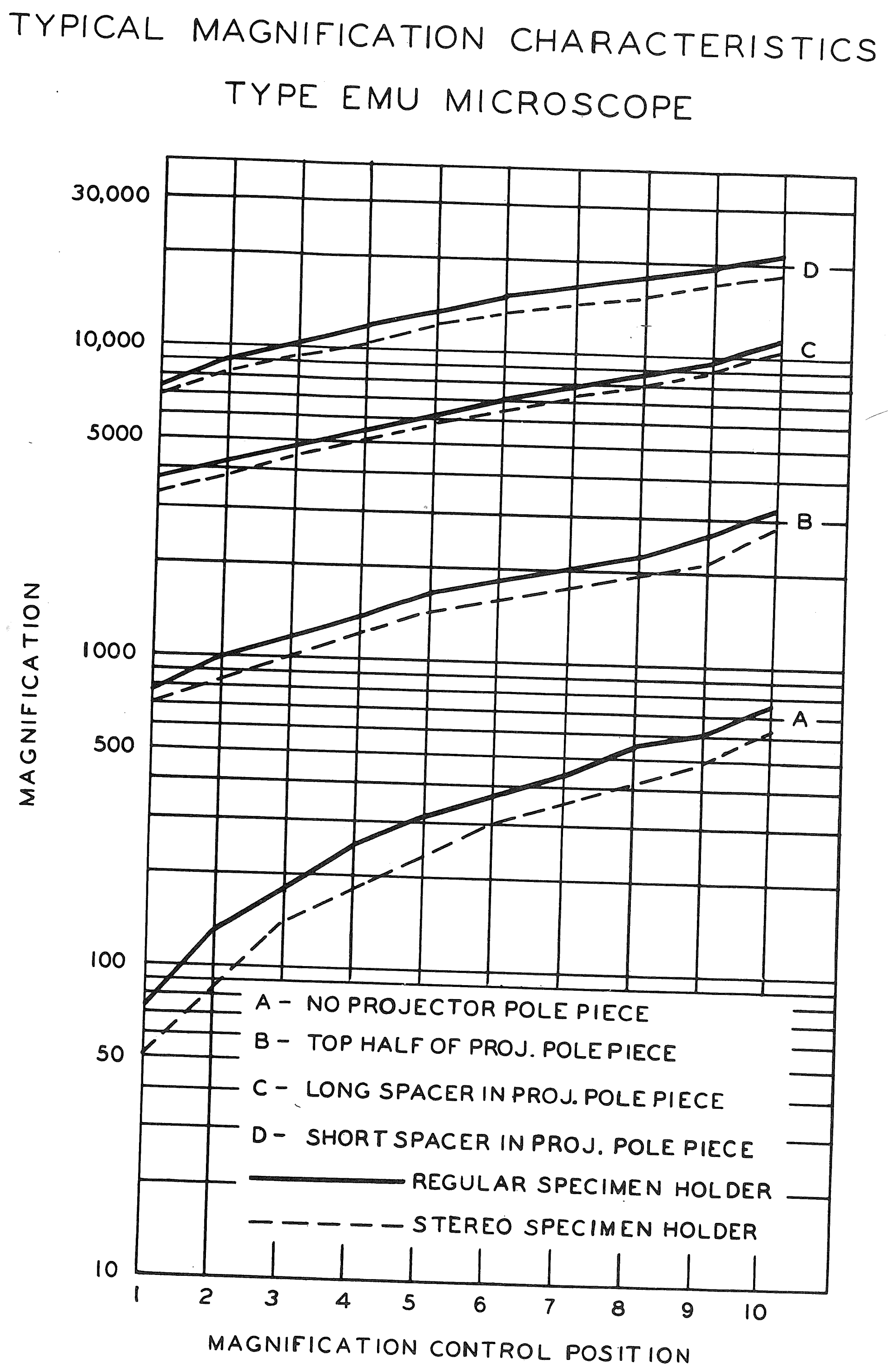
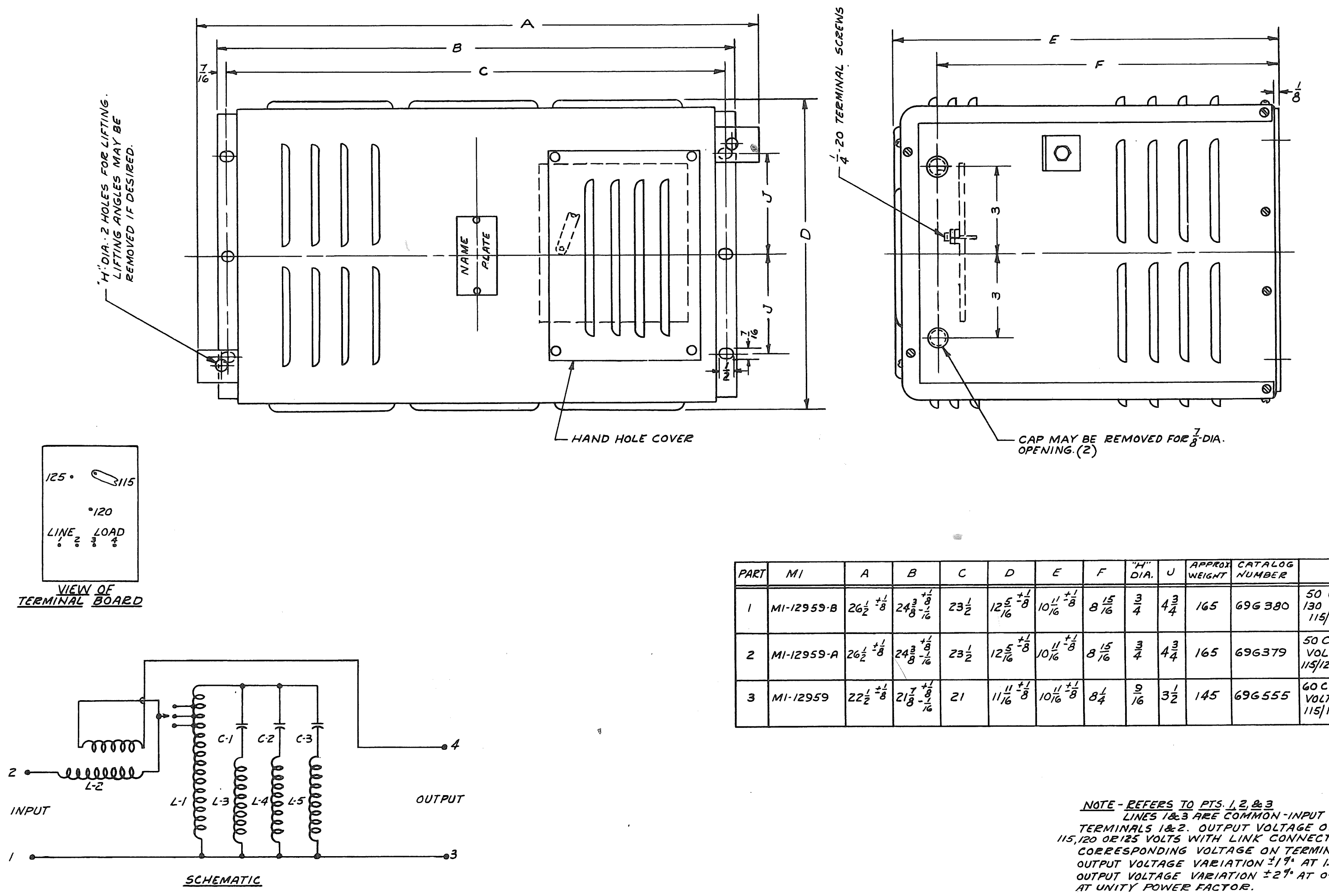


Figure 78—Typical Magnification Characteristics (M-430558—Sub. 0)


A
B
C
D
E
F
J
3
$\frac{7}{16}$
$\frac{1}{8}$
"H" DIA. 2 HOLES FOR LIFTING. LIFTING ANGLES MAY BE REMOVED IF DESIRED.
NAME PLATE
HAND HOLE COVER
$\frac{1}{4}$-20 TERMINAL SCREWS
CAP MAY BE REMOVED FOR $\frac{7}{8}$-DIA. OPENING. (2)
125
115
120
LINE
LOAD
VIEW OF TERMINAL BOARD
INPUT
OUTPUT
L-1
L-2
L-3
L-4
L-5
C-1
C-2
C-3
1
2
3
4
SCHEMATIC

PART	MI	A	B	C	D	E	F	"H" DIA.	J	APPROX WEIGHT	CATALOG NUMBER	RATING
1	MI-12959-B	$26\frac{1}{2} \pm\frac{1}{8}$	$24\frac{3}{8} {}^{+\frac{1}{8}}_{-\frac{1}{16}}$	$23\frac{1}{2}$	$12\frac{5}{16} \pm\frac{1}{8}$	$10\frac{11}{16} \pm\frac{1}{8}$	$8\frac{15}{16}$	$\frac{3}{4}$	$4\frac{3}{4}$	165	696380	50 CYC.-1.0 KVA. 95 TO 130 VOLTS LINE 115/120/125 VOLTS OUTPUT
2	MI-12959-A	$26\frac{1}{2} \pm\frac{1}{8}$	$24\frac{3}{8} {}^{+\frac{1}{8}}_{-\frac{1}{16}}$	$23\frac{1}{2}$	$12\frac{5}{16} \pm\frac{1}{8}$	$10\frac{11}{16} \pm\frac{1}{8}$	$8\frac{15}{16}$	$\frac{3}{4}$	$4\frac{3}{4}$	165	696379	50 CYC. 1.0 KVA. 190 TO 260 VOLTS LINE 115/120/125 VOLTS OUTPUT
3	MI-12959	$22\frac{1}{2} \pm\frac{1}{8}$	$21\frac{7}{8} {}^{+\frac{1}{8}}_{-\frac{1}{16}}$	21	$11\frac{11}{16} \pm\frac{1}{8}$	$10\frac{11}{16} \pm\frac{1}{8}$	$8\frac{1}{4}$	$\frac{9}{16}$	$3\frac{1}{2}$	145	696555	60 CYC. 1.0 KVA. 95 TO 130 VOLTS LINE 115/120/125 VOLTS OUTPUT

NOTE - REFERS TO PTS. 1, 2, & 3
LINES 1 & 3 ARE COMMON-INPUT VOLTAGE ON TERMINALS 1 & 2. OUTPUT VOLTAGE ON TERMINALS 3 & 4 115, 120 OR 125 VOLTS WITH LINK CONNECTION TO CORRESPONDING VOLTAGE ON TERMINAL BOARD.
OUTPUT VOLTAGE VARIATION ±1% AT 1.0 KVA.
OUTPUT VOLTAGE VARIATION ±2% AT 0-1.0 KVA.
AT UNITY POWER FACTOR.
PURCHASE FROM GENERAL ELECTRIC OR EQUIVALENT.

Figure 79—Voltage Stabilizer Outline Drawing
(P-719101—Sub. 1)

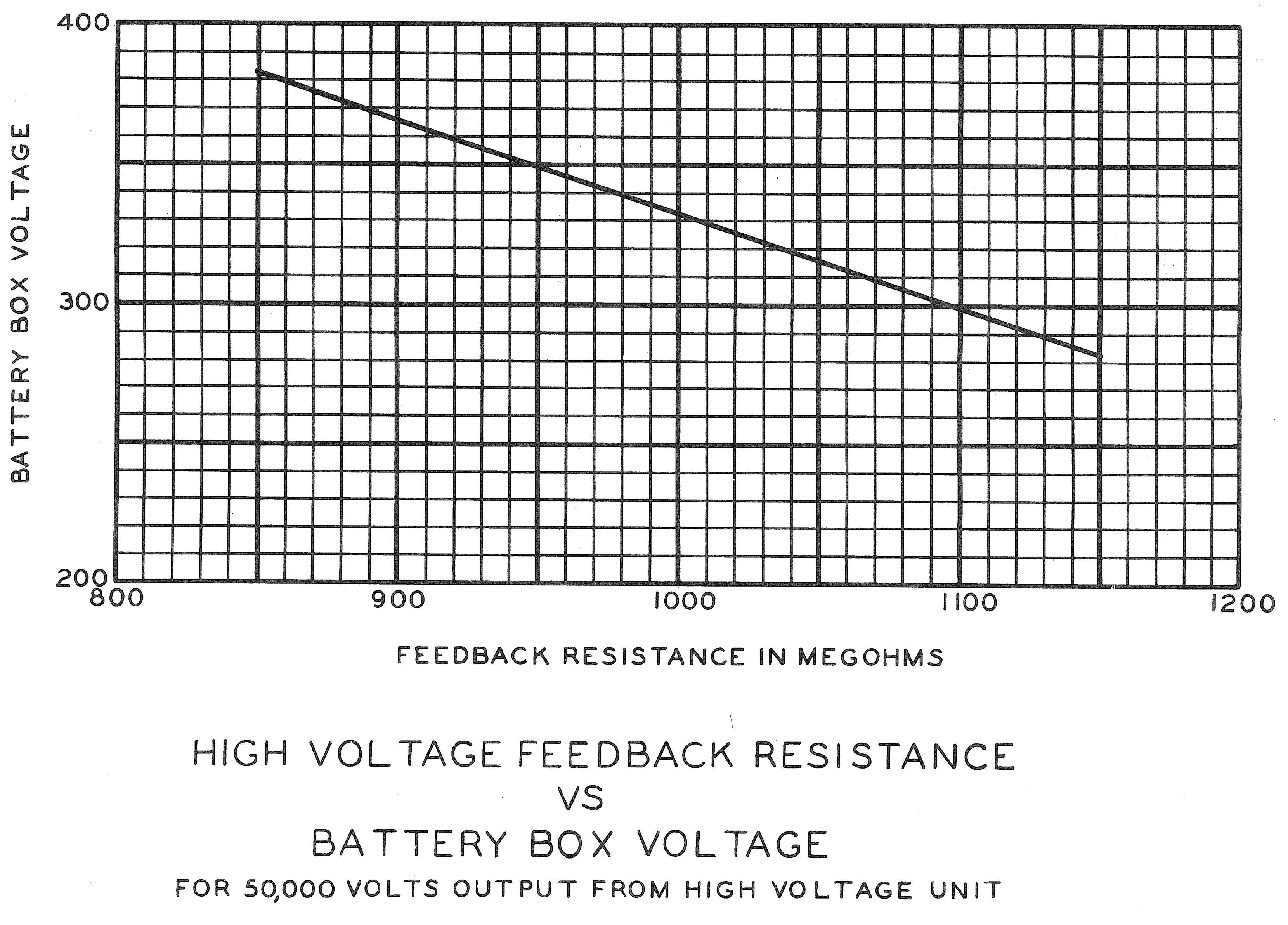


Figure 80—Chart for Battery Box Voltage
(M-439401—Sub. 0)

BATTERY BOX LAYOUT

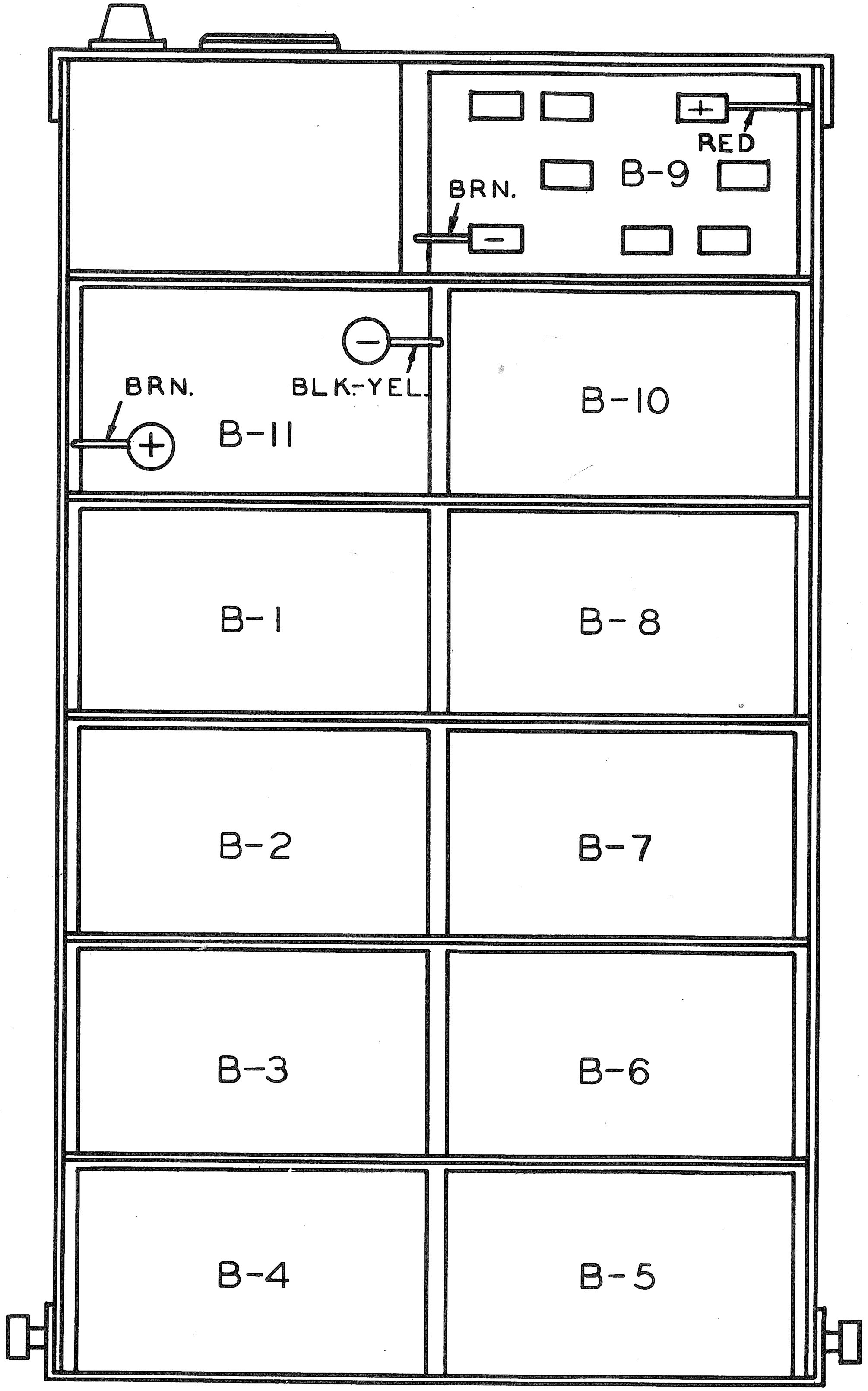

RED
BRN.
B-9
BRN.
BLK.-YEL.
B-11
B-10
B-1
B-8
B-2
B-7
B-3
B-6
B-4
B-5

Figure 81—*Battery Box Layout*
(*M*-439402—*Sub.* 0)